The Engineer

LONDON, FRIDAY, DECEMBER 26, 1941

PUBLIC NOTICES

BOROUGH OF WATFORD

WATER DEPARTMENT

APPOINTMENT OF WATERWORKS STATION SUPERINTENDENT

Applications are Invited for the APPOINTMENT of SUPERINTENDENT of the Corporation's Pumping Stations.

Applicants should be qualified mechanics and experienced in High-duty Worthington Pumping Engines, Deep Well Pumps and Electrically Operated Plant, and in the Supervision of Pumping Stations.

The salary will be at the rate of £420 per annum, rising by annual increments of £20 to £500, plus a temporary war period increase of 10 per cent. on the first £300 and 3 per cent. on the remainder. A residence is provided.

The appointment is a designated post under the Corporation's Superannuation Scheme, and the person appointed will be required to pass a medical examination and contribute to the Scheme.

Particulars of the appointment can be obtained on application to Mr. W. W. Newman, M. Inst. C.E., F.S.I., Borough Water Engineer, Town Hall, Watford.

Applications, accompanied by copies of three recent testimonials and endorsed "Waterworks Superintendent," must reach the Engineer not later than 5th January, 1942.

A. NORMAN SCHOFIELD,
Town Clerk.

Town Hall,
Watford. 8025

COUNTY BOROUGH OF BRIGHTON

APPOINTMENT OF ASSISTANT WATERWORKS ENGINEER

Applications are Invited for the APPOINTMENT of ASSISTANT WATERWORKS ENGINEER, at a commencing salary of £500 per annum. Candidates, who should be Corporate Members of the Institution of Civil Engineers, must have had considerable experience in a Waterworks Department, and must occupy a responsible position. They should have a sound knowledge of the Design and Maintenance of Steam and Electrical Pumping Plant, Service Reservoirs, &c., and the General Engineering Work of a large Waterworks Undertaking. The post is superannuable, and the successful candidate will be required to pass a medical examination before being appointed.

Particulars and conditions of appointment, together with form of application, may be obtained from the Waterworks Engineer, Mr. B. Cathcart, M. Inst. C.E., M.I. Mech. E., 32, Bond Street, Brighton, 1, to whom applications, endorsed "Assistant Waterworks Engineer," must be delivered not later than Monday, 5th January, 1942.

Canvassing, either directly or indirectly, will be a disqualification.

J. G. DREW,
Town Clerk.

Town Hall,
Brighton, 1,
15th December, 1941. 8036

TYNE IMPROVEMENT COMMISSION

APPOINTMENT OF ELECTRICAL ENGINEER

The Tyne Improvement Commissioners invite APPLICATIONS from qualified persons for the POSITION of ELECTRICAL ENGINEER under their Engineer-in-Chief, Mr. R. F. Hindmarsh, M. Inst. C.E. Applicants must be Corporate Members of the Institution of Electrical Engineers. They should have had practical experience in the design, operation and maintenance of Dock and Harbour Electrical Installations, both A.C. and D.C., and be competent to take charge of the maintenance of such installations, and also to draw up specifications for new works, &c.

Salary £700 per annum (excluding war bonus), rising by annual increments of £25 to a maximum of £800.

Applications, accompanied by not more than three recent testimonials, will be received up to the 12th of January, 1942, and should be addressed to the Chairman and marked "Electrical Engineer."

The person appointed will be required to reside in the district and devote himself exclusively to the service of the Commissioners, to submit to medical examination and be subject to the provisions of the Tyne Commission Superannuation Fund.

Canvassing will be a disqualification.

By Order,
J. K. McKENDRICK,
Secretary.

Tyne Improvement Commission,
Newcastle-upon-Tyne, 1,
16th December, 1941. 8047

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

The Engineer

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THE FACT that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

PERSONNEL MANAGER.—MAN of High character, with sound knowledge of Personnel Management, REQUIRED for Light Engineering Works in North-East London. Will be directly responsible to managing director and must possess wide executive outlook and, preferably, be a member of the Institute of Industrial Administration. Minimum salary £650.—Address, 8056, The Engineer Office. 8056 A

SITUATIONS OPEN

GENERAL WORKS MANAGER REQUIRED for Heavy Engineering Industry in South. Must have experience in modern management methods. Position offers great opportunity for man of ability. State salary required, age, education and experience.—Address, 8060, The Engineer Office. 8060 A

SHIFT ENGINEER REQUIRED, Thoroughly qualified to Take Shift Charge of High-pressure Steam-raising Plant, Turbo-generators, and all auxiliaries. Permanent appointment in Home Counties. Salary, £366 per annum. Pension scheme.—Address, stating age, experience, and enclosing copies of testimonials, 8037, The Engineer Office. 8037 A

PUBLIC NOTICES

THE RIVER GREAT OUSE CATCHMENT BOARD

FLOOD PROTECTION SCHEME

Engineer or Senior Draughtsman REQUIRED, with good knowledge of the Design of Masonry and Concrete Sluices and Reinforced Concrete Road Bridges.

Engagement for about one year, subject to one month's notice on either side.

Salary, £40 to £50 per month, according to qualifications.

Also DRAUGHTSMAN REQUIRED with Steelwork Experience, preferably on Sluice or Lock Gates.

Engagement for about one year, subject to one month's notice on either side.

Salary, £20 to £26 per month, according to qualifications.

For forms of application, apply to—
W. E. DORAN, B.A.I., A.M.I.C.E.,
Engineer to the Board,
"Elmhurst,"
Brooklands Avenue,
Cambridge,
12th December, 1941. 8031

CORK DOCKYARD LIMITED

APPOINTMENT OF MANAGER

Applications are INVITED for the POSITION of MANAGER of RUSHBROOKE SHIP REPAIRING DOCKYARD, CORK.

Candidates must apply in writing, giving particulars of age, qualifications and experience, and indicating salary expected.

References (copies only), which will not be returned, should be enclosed.

Applications to be sent before 21st January, 1942, to
THE SECRETARY,
CORK DOCKYARD, LIMITED,
13, Merrion Square,
Dublin. 8061

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1940 No. 877

RESTRICTION ON ENGAGEMENT ORDER

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CLASSIFIED ADVERTISEMENTS CLOSE FOR

PRESS-NOON WEDNESDAYS

The Engineer
Annual Subscription Rates

(including postal charges).

BRITISH ISLES ... £3 5 0
CANADA... ... ... £2 18 6
ABROAD £3 3 0
(except Canada)

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next date, February 27th.

ADVERTISEMENTS.

The Charges for Classified Advertisements are 1/- per line up to one inch—minimum charge, 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.

Teleg. Address,
"Engineer Newspaper, Estrand, London."
Tel., Central 6565 (10 lines).

SITUATIONS OPEN

TECHNICAL WRITER WANTED IMMEDIATELY to Prepare Intelligible Assembly and Dismantling Details for important Aircraft Instruction Books. Ability to read blue prints essential. Some practical engineering experience an advantage. Permanent.—Address applications (in confidence), 8053, The Engineer Office. 8053 A

THE Post You Are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing Your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for a cost of Four Lines, 4s.; 1s. for each Additional Line. There is no better way of covering so large a field for such a small charge.

SITUATIONS WANTED

ACCOUNTANT, Qualified, Age 43 (Reserved 30), SEEKS EXECUTIVE APPOINTMENT; 9 years' company secretary and 13 years one firm of chartered accountants; thorough knowledge accounts and costing; used to staff control.—Address, P3719, The Engineer Office. P3719 B

BUYER (40) DESIRES CHANGE, General engineering; experience workshops, drawing-office and general management.—Address, P3726, The Engineer Office. P3726 B

ENGINEER, Age 38, Experienced in All Types of engineering, including marine, chemical, mechanical (including maintenance, plant, buildings and power), at present works manager aeronautical engineers, REQUIRES MANAGERIAL POSITION. Free immediately, experienced designer, planning, costing, estimating and buying, Ministries and Controls. Excellent connection.—Address, P3734, The Engineer Office. P3734 B

ENGINEER (B.Sc.), Age 51, SEEKS EXECUTIVE POST. Wide experience machinery sales, home, Continent, Far East, and recent management modern die casting factory.
Address, P3732, The Engineer Office. P3732 B

ENGINEER, Aged 40, with Over 20 Years' experience in all grades up to and as manager, SEEKS MANAGERIAL POST which includes or leads to Directorship. Familiar Controls and Ministries. Has proved capacity to produce at war tempo. Highest business connections.—Address, P3718, The Engineer Office. P3718 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 4s.; each Additional Line, 1s.; Box Numbers, 6d. extra, which includes despatch of all replies.

LADY TRACER, Fully Experienced, REQUIRES POST; capable of taking responsibility, any district.—Address, P3731, The Engineer Office. P3731 B

METALLURGIST, Over Military Age, Resident Birmingham, WANTS POSITION as REPRESENTATIVE for the Midlands, or would act as outside Progress Man.—Address, P3728, The Engineer Office. P3728 B

PARTNERSHIPS

TO ENGINEERING AND ALLIED FIRMS.—Reputable BUSINESS FIRM WISHES to INVEST CAPITAL and take a WORKING INTEREST in GOING CONCERN. Light production preferred; 6000 square feet space available, if necessary.—Box 3068, Collins' Advertising, 26, Mortimer Street, W.1. P3709 C

PATENTS

IT is DESIRED to SECURE the Full COMMERCIAL DEVELOPMENT in the United Kingdom of BRITISH PATENT No. 473,720, which relates to "Pattern-controlled Machines for Milling, Die Sinking, &c.," either by way of the GRANT of LICENCES or otherwise on terms acceptable to the patentees.—Interested parties desiring copies of the patent specification and further particulars should apply to STEVENS, LANGNER, PARRY & ROLLINSON, 5 to 9, Quality Court, Chancery Lane, London, W.C.2. 8055 H

IT is DESIRED to SECURE the Full COMMERCIAL DEVELOPMENT in the United Kingdom of BRITISH PATENT No. 345,322, which relates to "Improvements in Friction Clutches," either by way of the GRANT of LICENCES or otherwise on terms acceptable to the patentees.—Interested parties desiring copies of the patent specification and further particulars should apply to STEVENS, LANGNER, PARRY & ROLLINSON, 5 to 9, Quality Court, Chancery Lane, London, W.C.2. 8051 H

MISCELLANEOUS

CANTEENS on War Work SUPPLIED with Fresh FRUIT and VEGETABLES. Quality our speciality, quantity no object. Our representative will call upon you by appointment.—Apply, A. ISRAEL, Ltd., 19, Piazza Chambers, Covent Garden (Temple Bar 8338). P3790 I

SUB-CONTRACTING

WANTED

WORK WANTED for 2 Rhodes Power Presses 2-ton cap., 2in. stroke; and for Spot Welder, 100 amp., cap. 3ft. 6in. arm, ¼in. added thicknesses.—C. S., Staffa Road, Leyton, E.10. 8042 MW

For continuation of Small Advertisements see page 64

FIELDING & PLATT
LTD.
GLOUCESTER
See our displayed Advertisement
SEPTEMBER 19

SKILLED HANDS WANT
PANDA
QUALITY TOOLS!

DELIVERY EX STOCK.
D.E. SPANNERS
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SIDE CUTTERS
TOGGLE JOINT NIPPERS
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TOP CUTTERS

Stock List sent on receipt of your request
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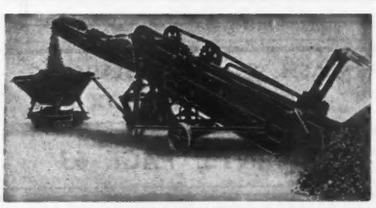

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POSITIVE SCRAPER LOADING MACHINE
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ENGINEERS **WIDNES, Lancs.**

MECHANS LIMITED,
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Steel Chimneys. Chemical and Gas Works Plant.
Riveted Welded and Pressed Steel Plate Work.
Special Machines to Clients Requirements. 6419

THE standardised card advertise below are inserted in place of firms' large advertisements which been omitted due to the paper sho

ALFRED HERBERT Ltd
COVENTRY
See our displayed advertisement on Page 13.

The Clews Petersen Piston Ring and Engineering Co. Ltd
Mill Lane, West Hampstead, London
See our displayed advertisement DECEMBER 12

KORTING BROTHERS
(1917) LIMITED
Sheepbridge Lane, Mansfield, Notts
See our displayed advertisement NOVEMBER 28

MIRRLEES WATSON CO., LTD.
SCOTLAND ST., GLASGOW
See our displayed advertisement NOVEMBER 28

JAMES NEILL & Co.
(SHEFFIELD) LIMITED
SHEFFIELD, 11, ENGLAND
See our displayed advertisement DECEMBER 12

Samuel Osborn & Co.
LIMITED
SHEFFIELD
See our displayed advertisement DECEMBER 5

Vertical Milling Machi
all geared, hardened and ground throughout, and roller bearings, swivelling head, 30"x8"
HENRY MILNES LIMITED, Machine Tool
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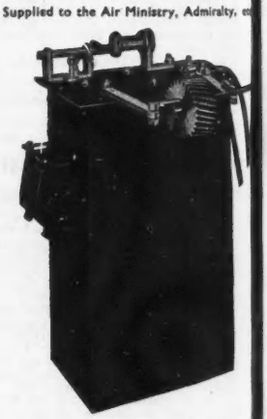
THE JOHNSON-FEL CRACK DETECTOR
Supplied to the Air Ministry, Admiralty, et



This illustration shows the Type R Machine testing a gear wheel with the Ring jig. Lever-head and cables in use.

The robust construction, perfect safety of operation, and easy handling makes this machine particularly suitable for quantity production work. Adaptable for use on all Magnetic materials.

★ *Please write for particulars and details of various models available*

FEL-ELECTRIC LIMITED
63 Gell Street, Sheffield, 3
England
Telephone: 20795 Telegrams: "Detector"

A Seven-Day Journal

German Warships at Brest Again Bombed

ON December 23rd the Air Ministry news revealed that the examination of the aerial photographs taken on Thursday, December 18th, during the daylight attacks on the German battle-cruisers "Scharnhorst" and "Gneisenau" at Brest had indicated that this was one of the most remarkable instances of accurate bombing under heavy fire. The ships were attacked as they lay in two dry docks side by side, and heavy armour-piercing bombs were used. The report says that it is certain that one bomb fell between the starboard side of the "Gneisenau" near the stern, and the side of the dry dock in which she lay. The distance between the ship and the side of the dock is only 20ft. or 30ft., and the effect of an explosion in this confined space would be appreciable. Similarly, another bomb fell between the port side of the "Scharnhorst" near the stern and the side of her dock. There is reason to believe, though the confusion of smoke precludes certainty, that a heavy bomb fell amidships and penetrated the deck of the "Scharnhorst." The gates of the two docks were closed at the time of the attack. Both gates slide into a recess between the docks when they open and this recess has had a direct hit. It is reasonable to suppose that the mechanism of the dock's gates has been damaged, and that the ships cannot be moved until it has been repaired. A great number of bombs also fell close to the ships. The important submarine pens at Brest were also heavily bombed during the attack, and received one certain and two probable hits. Buildings, possibly workshops behind the submarine pens, have been demolished. Not one bomb fell in the town or in the commercial port of Brest. The bombing was from a great height in order to enable the bombs to penetrate the ships' armour, and it was therefore necessary for every aircraft to make a steady bombing run, even while the fiercest barrage was being sent up by the Germans. The warships themselves, each with anti-aircraft guns, contributed to the barrage, and, apart from this, Brest is one of the most heavily defended of all targets.

Dr. C. C. Paterson's Appointment

IT is announced by the General Electric Company, Ltd., that Dr. C. C. Paterson has joined the board of the company. Dr. Clifford Copland Paterson was born in 1879 and received his education at Mill Hill School. After serving a four years' engineering shop apprenticeship he continued his technical training at Finsbury Technical College and Faraday House. From 1901 to 1918 he was at the National Physical Laboratory with Sir Richard Glazebrook, where he was Principal Assistant responsible for Electrotechnical and Photometric Departments. He then joined the General Electric Company, Ltd., in order to establish and direct the research laboratories. Up to the beginning of the war the G.E.C. research organisation had grown to number over 500 people, and it is amongst the largest in the country with a world-wide reputation for scientific and technical achievement. Dr. Paterson is a Past-President of the Institution of Electrical Engineers, of the Institute of Physics, of the Illuminating Engineering Society and other bodies. He is a member of the Institution of Civil Engineers. He has served as a member of the Executive Committee of the National Physical Laboratory, as Vice-President of the Royal Institution and of the Society of Arts, as chairman or member of various Government Departmental Committees on technical subjects and is now a member of Lord Hankey's Engineering Advisory Committee. He is Chairman of the Electrical Industry Committee of the British Standards Institution. Dr. Paterson's main personal contributions to science have been in the field of lighting and vision. He has been Faraday Lecturer of the Institution of Electrical Engineers, Guthrie Lecturer of the Physical Society and Huxley Lecturer of Birmingham University. In 1937 he received the D.Sc. degree (*Honoris Causa*) from Birmingham University.

A Merchant Ship for Norway

ON Friday, December 19th, an interesting event took place at a northern shipyard, when the first merchant vessel to be built in Great Britain to replace Norwegian shipping losses was launched. She was named the "King Haakon VII" by Mrs. Sunde, the wife of the Royal Norwegian Minister of Supply and Shipping. The motorship is a 7000-ton vessel. The ceremony was attended by his Majesty King Haakon of Norway, Mr. Arne Sunde, the Royal Norwegian Minister of Supply and Shipping; Lord Leathers, the Minister of War Transport; and other representatives of the British and Norwegian Governments. The launch marked the beginning of a scheme whereby merchant ships built in this country will become available to Allied Governments that have suffered severe shipping losses. At a dinner following the launch, King Haakon paid a tribute to the goodwill which had been shown in the negotiations which had taken place in connection with the replacement of Norwegian shipping. Lord Leathers, in his reply, said that the Ministry of War Transport had more than 3,000,000 tons deadweight carrying capacity of Norwegian shipping on time charter. Mr. Sunde, who spoke on Norway's shipping losses, revealed that during the twenty months that his country had been in the war a total of 173 ships, aggregating close upon 750,000 gross tons, had been destroyed by enemy action. During the first five months of the present year Norway had lost an average of 49,000 tons of shipping per month, but during the last six months that loss had decreased to an average of 17,000 tons per month, a figure which was about the same as that sustained by Norwegian shipping during the seven months before Norway was invaded. It was also stated by Mr. Sunde that about 40 per cent. of the petrol used in Great Britain and by the fighting forces was carried in Norwegian tankers.

Extended Control of Civil Building

IT is announced by the Ministry of Works that, as from January 1st, 1942, a revised Defence Regulation 56A will come into force, which will extend the existing control over work of construction, reconstruction and alteration, to include repair (including the repair of war damage), maintenance of premises, decoration, demolition, and protection of premises against hostile attack. The position after January 1st, 1942, will be that no operation, consisting of work of any or all of the above categories (excluding maintenance) will be permitted in the United Kingdom if the total cost of such operations exceeds £100 unless a licence to carry out such work has first been obtained from a Regional Licensing Officer of the Ministry of Works and Buildings. In addition, no work as above-mentioned (including maintenance) may be carried out on any single property in the United Kingdom if the cost of such work, together with the cost of any other such work carried out on that single property during the twelve months immediately preceding, exceeds the sum of £100 unless a licence has first been obtained in respect of such work. The twelve months' period will be reckoned as the twelve months immediately preceding the date of application. The position as regards local and highway authorities and public utility undertakings remains unchanged. Such authorities and bodies require as at present to obtain an authorisation from the appropriate Government Department for work of construction, reconstruction and alteration only, the cost of which exceeds £100. In computing the cost of an operation or work for which an authorisation or licence is required the value of materials (whether new or second-hand) in the possession of the building owner or his agent and the cost of labour, overhead charges, profits and fees for professional services, such as architects' and engineers' fees, must always be included.

Handicaps to Industrial Progress

SPEAKING at the recent annual general meeting of Birmid Industries, Ltd., in Birmingham, Mr. Percy Pritchard, the deputy chairman and joint managing director of the company, protested against the inadequacy of the wear and tear allowances for inland revenue purposes. These, he said, combined with the present high taxation, made it impossible for industry to give the maximum assistance to the national war effort which it would like to do and otherwise could do. The level of taxation to-day, Mr. Pritchard went on to say, was such that, combined with the inadequate wear and tear allowances, it became impossible for many firms to provide the necessary funds which were required to meet really essential expenditure on the plant and equipment necessary for the purpose of increasing production. A further, and possibly even more serious, hindrance to the national effort was the effect of the dead man's hand on production caused by over-centralisation of Government control departments. When it came to consideration of projects or course of action to be decided, no latitude or discretion was given by the powers that be in the Government to the man on the spot to say "Yes." Approval could only come from higher up, and not infrequently had to be given through the medium of several committees with consequent ages of delay. On the other hand, when it was a matter of informing industry what it was not allowed to do there seemed to be hordes of officials who were endowed with plenary powers in that respect.

Munitions in the Homes

IN a broadcast message on Sunday, December 21st, Lord Portal, the Joint Parliamentary Secretary to the Ministry of Supply, appealed to every individual to help in the great drive for salvage. All, he said, had potential munitions of war in their homes, and it was a matter of the greatest urgency that the materials for which he was asking should be given up. Those materials, although often of no value to the individual, were priceless to the country. From the moment that Japan struck at the British Empire and the United States the demands on our resources had been tremendously increased, and the shipping available to bring essential war materials from overseas had been reduced. It was very necessary for everyone, said Lord Portal, from now on, to make a special effort to save shipping space. Paper helped to make radio sets for tanks and bombers, land mines, sea mines, shell cases, A.A. shells and machine gun bullets. Old magazines, newspapers, old Christmas cards, wrapping paper, food cartons, and cigarette packets should never be thrown away. Scrap metal was required even down to bent nails. Another source of good scrap metal had been railings, of which already 5000 tons had been taken from public and private buildings and parks in London, but borough surveyors and others scheduling property for railings salvage had met with much opposition from property owners. A new Order made by the Ministry of Supply, which had just come into force, prohibits the disposal of the strippings and reel ends which are produced in the course of printing, and of any waste paper so produced except for the purposes of repulping.

The Engineer in Malaya

By Professor C. A. MIDDLETON SMITH, M.Sc., M.I. Mech. E., LL.D.

No. II

(*Continued from page 428, December 19th*)

Military Movements and Roads

SOME years ago, while on leave, we made a tour of the war areas in France, mainly to warn our boys about the mistakes made by my generation. Little did we think then that those boys, in 1941, would be in military uniform in India, Malaya, and Shanghai. We had with us as guide a French padre who had been an interpreter on Haig's staff. Whenever we came to a really good road surface he would say, "The British repaired that road."

Memories of those roads in France has reminded me that it is probable that Malaya may benefit in road construction, because of the increased need for rapid transport all over the peninsula. Military mechanised vehicles will necessitate reconstruction of many existing roads, for it was assumed that local conditions would not require the use of vehicles of the weights common in European industrial countries; and so it seemed to be unnecessary to build to the standard of the Ministry of Transport in Britain in the areas outside of Singapore Island. The bridges were designed to carry a load equivalent to two-thirds of that demanded in England.

My guess is that, as a result of defence preparations, more roads will be built in the eastern side of the peninsula, for large areas there are undeveloped. The coastline is inhospitable with no good natural harbours. It is separated from the west coast by ranges of hills rising to peaks 7000ft. high. It is exposed to the monsoon winds. The west coast has good harbours and is shielded by hills from the east winds. It is blanketed from the west and south-west by the folded mountains of Sumatra.

The rainfall is everywhere sufficient to make the whole of Malaya one vast stretch of forest, some of it very dense jungle, still untrodden by man. In the east the rainfall reaches 150in. and is nearly 100in. in other parts.

The restriction of tin and rubber output caused the Government to employ a large labour force on road and other works in 1938. In one State, Perak, where the cut in the tin quota was felt severely, the expenditure in one year on unemployment relief works was about £40,000. Some 5778 labourers were employed on wages averaging about 1s. a day.

Although the P.W.D. engineers realised that contractors would have carried out the relief works more cheaply, and would have saved the overworked P.W.D. staff much extra trouble, they knew that the resulting poverty of the coolies would have made some form of Government subsidy essential. The Chinese contractor has no sentiment about providing a living wage! It is recorded that a contract for earthwork was made at the rate of 18 cents per cubic yard; this contract was promptly sublet at the rate of 12 cents, and the coolies were finally paid at the rate of 8 cents! Chinese contractors form rings and hold up the Government and labour to ransom unless dealt with very firmly.

Schemes involving earthwork were considered to be most suitable for the solution of the problem of unemployment; some action was imperative to prevent riots and other crimes. The useful improvement in the roads, &c., not only provided a living wage for many thousands of coolies, but helped the shopkeepers who otherwise would have been in distress. The unemployment works included the levelling of large areas of land, the desilting and realignment of streams, and important work on the Ipoh aerodrome, the landing area of which was considerably increased. It is worth recording that the P.W.D. employed 25,000 labourers departmentally in 1938. There were no labour troubles and wages remained unaltered throughout the year.

The Water Supplies of Malaya

With the high average rainfall in Malaya, there should not be the great difficulties experienced in some tropical countries for the engineers concerned with water supply. The chief trouble has been concerned with finance, for the revenue that can be collected from a rural population is seldom sufficient to pay for a supply of pure water. However, it has always been one of the aims of the Government to provide a satisfactory supply. The P.W.D. is responsible for the work, except in the Settlements of Singapore, Penang, and Malacca, where most of the water supplied is under the control of the local municipality. The total cost of the controlled supplies administered by the P.W.D. approximates to about £3 million; in 1937 some 9745 million gallons was delivered to a population of 747,930, or 35·7 gallons per head per day. The almost sudden influx of a large number of troops, stationed in camps in different parts of Malaya, must have presented difficult problems of water supply.

It is noticeable that, in spite of the progress made, only about one resident in every five in Malaya had (in 1938) a supply of piped water. The most progressive States seem to be Perak, Pahang, and Selangor (Federated) and Johore (Unfederated). These employ specialist water engineers of the P.W.D., who are not only responsible for the strictly engineering work, but also for the control and development of the necessary purification and sterilisation processes. These States are relatively more wealthy than the others, mainly owing to their more advanced economic development.

The chief problem for the engineers is the supply of pure piped water to places in the coastal regions. On the west coast there is a rich alluvial plain producing a great deal of the agricultural wealth of Malaya. There is no water-bearing geological formation, as in England, which can be tapped by wells. Surface wells may dry up. Deep wells exist, but the water from the lower levels is usually acid and corrosive, which makes it unpleasant without complicated treatment. Similarly with infiltration water from rivers. While there are efficient wells, in general they are, as a source of supply, a failure.

It is notable that the specialist P.W.D. water engineers condemn the mechanical filters of proprietary manufacture as unreliable, for the fittings deteriorate. This is due, no doubt, to the acid and corrosive nature of the water. The complicated proprietary mechanisms have been discarded and treatment worked out from first principles. It is of interest to note that some of the control apparatus designed in Malaya has been used in England and other countries. It is claimed by the P.W.D. officials that they are now supplying water, in both large and small plants, of a reliability not surpassed in many European cities.

The wealthy Unfederated State of Johore has spent a large sum of money on water supplies, its rapid expansion, due to its fertility and proximity to Singapore, justifying the expenditure. The Municipality of Singapore obtains its water supply from Johore State.

It can be said that the engineers no longer fear to use the sources of water that are subject to contamination. They have developed methods for the successful purification of the supply, but they emphasise that their use entails constant examination and supervision. The very simplicity of some processes is a danger, for it deceives both the Asiatic workman and the engineer who is not a specialist in this branch of the profession.

Although, in most places, the final responsibility for pure water rests with the engineer, a tribute is paid by the Director of the P.W.D. to the willing co-operation of the Health Department and the Institute of Medical Research.

Corrosion of pipes has been a trial to the engineers. Cast iron pipes have been standard for distribution, and the practice of lining them with spun concrete has found favour. Steel pipes, manufactured locally, are in use with concrete linings, but the soil of the country is so corrosive that the usual wrapping of hessian and bitumen has not saved them, and an adequate external coating has yet to be found. Asbestos pipes, under low pressures and small diameters, have been a success, and concrete pipes carry water under considerable pressure.

Services Rendered by Government Engineers

It is impossible to give in detail a description of the many and various types of works carried out by these engineers in the different States, but it may be mentioned that they included the preparation of sites for aerodromes, barracks, hospitals, schools, quarters for persons in Government employ, dams for reservoirs, dredging of channels, installation of water-borne sewage systems, anti-malarial drainage work, irrigation schemes, marine structures, surveys, the maintenance of a factory for the supply of new machinery, maintenance, repairs, and reconstruction of plant, automobile repairs, and supply of new vehicles, structural steelwork, and welding, &c.

There is also the very useful scheme for training Asiatic technical assistants, and there can be no doubt that, as time goes on and the work of the P.W.D. increases, more use will be made of the services of Asiatic professional engineers. Preference is rightly given to Malays with the required qualifications, but it was clear to me that Chinese and Indian university engineering graduates had a good case for better pay and prospects.

Airports in Malaya

The two most important airports are situated in the two most important seaports in the peninsula, viz., Singapore and Penang. It is reasonable to suppose that the defence of Malaya had led to the extension and creation of others. We may be sure that the P.W.D. engineers have been concerned with these new works.

The Director of the P.W.D. has described the Singapore airport as "a project which is not only audacious as an engineering achievement, but which sets Singapore in the forefront of international air transport."

The airport was opened by H.E. the Governor in June, 1937, and has been in regular use by Imperial Airways, Empire and local services, the Dutch lines, &c. The work of construction lasted for five years; it cost about three-quarters of a million pounds sterling. It covers 263 acres, and it involved the transport of nearly 9 million cubic yards of filling. There is a great sea-plane slipway of reinforced concrete, with wharf.

The original site was a tidal swamp with a bed of mud so soft that a pole could be pushed down for 50ft. without any difficulty. To tip earth into such a swamp is to form an uncontrollable muddy mass. The engineers had to isolate about a dozen areas, encircling each within a bank of hard earth, brought to the site by train to fill in a dredged channel. Finally the man-made stable islands of hard earth were joined up to form the aerodrome.

A fine tribute was paid to the P.W.D. engineers by the Governor at the opening ceremony. He said:

> "For the execution of the work we have to thank the Public Works Department. The airport stands to their eternal credit, and both they and we may well be proud of what they have achieved. Seldom, if ever, has a Government Department in the Colonies been entrusted with a task of such magnitude. In this ground that lies before you, in the buildings, in the construction of the slipway, and in the equipment and general lay-out you have clear proof of first-rate engineering and architectural skill and forethought."

Expenditure on Public Works

It is hoped that the brief outlines of the many and various activities of the P.W.D. given in these notes will convey some idea of the many interesting problems solved by the engineers in the service and the local difficulties which they had to surmount. During this century, until the recent threat by Japan, it was true to say that Malaya was, on the whole, a land of peace and plenty. It was affected by the world trade depression of about ten years ago, and troubled by the reduction in the tin and rubber quotas in 1938, but on the whole British Malaya has been one of the most prosperous portions of the British Empire. The great influx of immigrants and the increase in revenues of the Governments is proof of prosperity.

The total annual expenditure of the P.W.D. seems to have reached a maximum of about £6,240,000 in 1928 and a minimum of about £1,680,000 in 1934. The total expenditure in 1938 was about £3,590,000; the Drainage and Irrigation Department spent another £193,000. Singapore absorbed more than half of the £900,000 spent by the P.W.D. in the Straits Settlements; Perak spent about £600,000 of the total of £1,630,000 spent in the four Federated States; the very prosperous State of Johore—near to Singapore—spent about £800,000 out of a total P.W.D. expenditure of £1,210,000 in the Unfederated States.

In all Asiatic countries there is the reasonable ambition of educated natives to obtain employment. Unfortunately, a very great mistake was made by British administrators in Asia during the nineteenth century, in encouraging the study—in the English language—of purely literary subjects. Technology was almost ignored. Nowadays there are a number of scientifically trained Indian, Chinese, and other Asiatic engineers, and every encouragement should be given to them so as to induce young Asiatics to study applied science subjects. Native rulers wish to provide employment for their own subjects.

A note by Mr. G. O. Dorrity, Acting State Engineer in the Unfederated State of Trengganu, is of interest. He wrote:

> "Until the State is in a position to supply its own requirements of technical assistance, the present disinclination to employ outside men is likely to be a serious handicap to the officers responsible for the expenditure of the Special Service Votes."

It is, the writer believes, essential to have complete co-operation between European engineers with experience and scientifically trained Asiatic assistants who will gradually be able to fill responsible positions.

In Malaya engineers in various services were so generous and patient in giving their limited leisure in order to explain to me their work that it seems a poor return not to enlarge upon their successes. It will be obvious to engineers in the P.W.D. that some of the detailed information about their work has been gleaned from the excellent annual reports signed by the Director-Adviser, Major R. L. Nunn, and by Mr. F. G. Coales (Acting), during the absence of his senior on leave. It may, however, be mentioned that it was my privilege to see much of the work in progress; if due credit has not been given to particular individuals it is because all of the numerous staff at work for the P.W.D. have a claim to receive the thanks of anyone capable of realising their difficulties, and the able manner in which they have performed their strenuous duties.

The Drainage and Irrigation Department

This establishment (separated from the P.W.D.) consisted in 1939 of the Director-Adviser (Mr. A. G. Robinson, B.Sc., M. Inst. C.E.), the Assistant Adviser, and twenty-five other civil engineers, with a leave reserve of four officers. There were eighty-four technical assistants and twenty-seven surveyors, all presumably Asiatics. The total staff, including draughtsmen, clerks, storekeepers, &c., was 348.

Since its formation in 1932 the department has completed or had under construction schemes to make available from virgin jungle 85,000 acres, at an estimated cost of £400,000. Work has also been done that provides new means for the improvement of irrigation and drainage for existing or abandoned areas covering 65,000 acres, costing about £200,000. Investigations have been completed or were well advanced concerning 25,000 acres of further new land and the improvement of many acres of existing lands. All over Malaya planters consult the department and receive advice concerning the solution of their drainage problems; often a number of estates combine to concentrate on a comprehensive scheme, which one estate would be unable to finance.

The Governments of Malaya experienced great labour difficulties some years ago owing to rice shortage, which in 1928–30 cost the Government nearly £5,000,000 in rice subsidies. Since then great efforts have been made to increase rice production in Malaya, obviously a matter of vital importance in wartime. Until the department was formed, ricefields, year by year, were going out of cultivation. Not a single irrigation scheme had been created since 1906.

Rice cultivation is nearly always dependent on a supply of running water. As an example of the quantity needed for irrigation, a contract was let in 1938 to irrigate 24,000 acres with some 324 million gallons of water a day from the Batang Pedang River. There are now at least 735,000 acres under cultivation for rice in Malaya. The yield annually was about 300,000 tons (1935), but, even so, in that year 475,000 tons of rice was imported. It is obvious that if the country can increase the quantity of the staple food of the people, the rural population will have more profitable employment and their scale of living will gradually rise.

Mr. Robinson has planned and organised a department that has done more than encourage rice production. It has carried out valuable reclamation schemes and has fought a relentless campaign against that deadly foe—malaria.

Local Irrigation Problems

Irrigation methods in use all over the world have certain principles in common, but in every country the evolution of schemes by the natives should be studied. Failure to understand local conditions in Malaya before the creation of the department often caused cultivators to despair, for they had been given advice which was worse than useless when put into practice.

It is encouraging to know that the success obtained by the staff of the department in the F.M.S. and Straits Settlements has recently led cultivators in the Unfederated States to seek their advice. Thus in Johore about 3000 acres of ricefields had been affected adversely by the silting up of the Muar River, and the trouble was remedied. It is estimated that at least 100,000 acres of deep swamp and dense jungle could be reclaimed for rice cultivation in this State. But such work demands careful planning.

In the State of Selangor, coastal lands have been bunded—a total of 73 miles of sea walls—to keep out salt water. The land enclosed was drained. One result was that the yield of cocoanuts was doubled. Records show that intensive irrigation of these plantations results in an increase in size of the nut by as much as 20 per cent.

River Conservancy and Hydro-electric Schemes

Until about sixty years ago Malaya was almost entirely a land of virgin jungle; there was little demand for inland transport. The rivers were allowed to adjust themselves to local conditions. But the comparatively recent and rapid developments in mining and agriculture, causing erosion and the deposition of silt, have raised the river beds, widened courses, and increased flooding in low land areas. Clearing the land for plantations has increased the rate of run-off; mining has created difficulties. Mines may be worked out in ten or twenty years; owners are more concerned with dividends than with neighbouring property, or posterity, so that they have resented any expense due to the preservation of other property. It has been notable, however, in recent years, that mineowners have co-operated more closely with the department. Much work has been done in connection with river deviations and silt retention schemes in areas where there is tin mining. Thus, in the Kinta Valley a scheme for excavating 30 miles of new river channel through dredged ground has been prepared, after intensive research in the department's hydraulic laboratory. This scheme will enable mining companies—who will share the cost of the deviation—to mine the old river bed. Deviations on a tributary of the river have already been completed by the department and paid for by mineowners.

Five annual reports of the department have been issued. They are most valuable records of the difficulties overcome, the engineering works completed, the data and experience gained in the field and the research laboratory. In the report for 1938 there is quoted an extract from THE ENGINEER of November 11th, 1938, concerning problems of soil erosion. It is as well to emphasise one

sentence from this extract, which reads :—"The thesis here advanced is that the ruin of this country is not due to a secular of climate nor to warlike operations—though these have helped—but to man's ignorance and greed."

The bold measures taken by the Government after the 1926 floods eliminated the almost intolerable conditions that existed in the urban areas of Kuala Lumpur and Ipoh, and demonstrated the immense importance of river conservancy works.

These two largest towns in the F.M.S. had become engulfed in several feet of water, and traffic by road and railway had been almost at a standstill. Work for the mitigation of floods has consisted of (1) canalisation, (2) flood embankments, (3) silt retention reservoirs, (4) river training, (5) dredging.

The able manner in which during the last ten years the engineers in Malaya have solved the numerous technical problems of flood relief for towns and agricultural lands enables us to hope that the experience and data accumulated will stimulate similar work in other countries in the Far East. In China, Indo-China, and Thailand, every year floods create terrible devastation and often great loss of life.

There does not seem to be any possibility of extensive hydro-electric development in Malaya. The Perak River scheme supplies the network in the mining area of the Kinta Valley. In this scheme the hydro-electric supply is supplemented by two steam stations with a capacity of 30,000 kW and 21,000 kW. The great advantage of electric power in tin mining is mobility of equipment.

The work accomplished by the engineers of the Drainage and Irrigation Department of the Malay States has not only greatly increased food production and employment; it has eliminated malaria from some districts. It has, above all else, demonstrated that the tropics can be made habitable, and even healthy, if engineers are given the opportunity and the funds to carry out their plans.

MINING IN MALAYA

There is considerable mineral wealth in Malaya. The most important product is tin, for about one-third of the world's total output is supplied by Malaya. Tungsten and iron ores and manganese are mined, while gold is obtained by the Raub Australian Gold Mines and Asiatic concerns. In the sixteenth century Malaya was more famous for gold than for tin, but the output from mines in other parts of the world has made Malayan gold less significant.

A coalfield in Selangor State provides fuel for mines and railways. China clay (kaolin) of excellent quality is obtained in the State of Perak. Tin was worked in this part of the world by Malays, Chinese, and Siamese centuries before British influence was established. It was the fighting by rival factions of Chinese tin miners that caused the British to interfere in the administration of the native States.

Malayan tin deposits are mainly alluvial, and are mostly on the western side of the peninsula. In these deposits the ore resembles a dark crystalline sand.

The Chinese owners generally use primitive methods of working the alluvial deposits, using but little machinery. One of my Chinese graduates took me to a mine which he proudly informed me was "the biggest hole in the earth made by man." The tin-bearing soil was excavated by hand and conveyed up the long slope by trucks to sluice boxes where it was washed and freed of impurities.

The most recent and very successful method of alluvial tin mining is by large floating dredgers that carry a power plant for causing an endless band of buckets to rotate and for working pumps, &c. It is astonishing to see in the jungle what seems to be a big steamer, floating in an excavation filled with water. You see the buckets coming up out of the water surface, passing the dredged material into a revolving cylindrical screen, where it is broken up by jets of water playing on it. The tin is recovered by passing the mixture through sluice boxes. The dredger digs ground in front of itself and dumps waste material behind, so that the dredger and the pond in which it floats are constantly moving deeper into the unworked land, often jungle. Much of the advantage of this method of mining is that mines formerly abandoned as worked out have been profitably and inexpensively mined again.

It was my privilege to spend several hours on board one of these large floating dredgers. On the upper deck a walk across an unguarded narrow sheet iron gangway, with clanking machinery on the decks below, was, for me, a frightening experience, but the staff of the dredger were unconcerned.

Practically all of tin ore mined in Malaya, and a good deal from adjoining places, is smelted into metallic tin at the works of the two great smelting concerns, the Straits Trading and Eastern smelting companies. Tin ore from Siam, &c., is also sent to Penang or Singapore. In tin mining the labour is supplied by Chinese.

British officials, when they assumed responsible positions in the native States, realised that increased revenue could be obtained from mining taxation. They therefore pushed forward road construction and schemes to improve navigation on rivers, &c., in order to encourage mining enterprise.

In the rubber, palm oil, and pineapple (canning) industries, machinery is used, and Malaya has proved a good market for British engineering firms.

LABOUR AND FORESTRY EPARTMENTS

My long experience in the Far East left a deep impression on my mind concerning the integrity of the British officers in the service of Governments in that part of the world. Residents at times complain that these officials are obstructive, even stupid, but it has never been suggested to me that there has been a single case of corruption. That is the more remarkable when it is realised that the Oriental has a wonderful subtlety in the art of what we call bribery, but which he considers a legitimate business proposition.

The Atlantic Charter has emphasised the importance of the economic development of tropical lands and the improvement of the standard of living for the natives. No praise is too great for the Governments of Malaya for their pioneer endeavours to do both these things. The British officers in the Labour Department care for the Chinese and Tamil workers to a degree that amazed me, and the workers trust them implicitly.

Mention must be made of the efficient Forestry Department, for these officials are aiding in a scientific manner the economic development of Malaya.

In conclusion, it can be said that there is perhaps no part of the world that has benefited more than Malaya because of the introduction of scientific methods for the economic development of the natural resources of the country. In the astonishing transformation of Malaya, British engineers have taken a prominent part. If needs be, they will be as active and efficient in the defence of the country as they have been in its economic development.

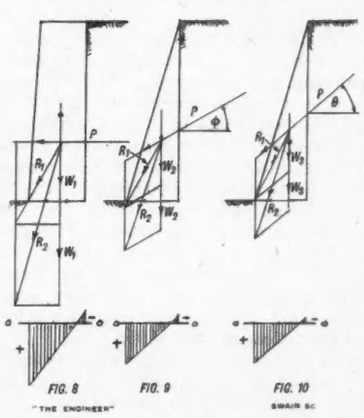
Foundations

By R. R. MINIKIN

No. II

(*Continued from page 430, December 19th*)

IT will now be fairly clear that it is the presence of water in the soil that gives rise to most of the difficult foundation problems and those structures which have to withstand heavy lateral forces, such as retaining walls or dams, are the most exercising in this respect. In spite of the great progress in scientific method, most engineers in this country still pin their faith and practice to the Rankine theory of earth pressures as applied to retaining walls, notwithstanding the more exact analysis of the Wedge theory in the form propounded by the Building Research Board, or that developed by the author. Generally all the relevant formulæ take the form $P = C\frac{w h^2}{2}$ and the difference between them lies in the value of the coefficient C; the height of the centre of pressure above the base and the direction of the resultant of the earth pressure. Rankine, basing on the hydraulic analogy, places the centre of pressure at one-third the height ($0 \cdot 33\,h$), the revised wedge theory (Jenkin) at, on the average, $0 \cdot 4\,h$, and the author in all cases at $0 \cdot 5\,h$. Rankine fixes the direction of the resultant of earth pressure parallel with the top surface; the revised wedge theory at the angle ϕ to the normal to the back of the wall and in the Minikin theory the direction is the line passing through the centre of gravity of the slipping wedge and the half point of the back of the wall. The author would wish to emphasise that in his theory the gravity forces conform to the generally accepted condition that they act through the centre of gravity of the affected body, which in other earth pressure theories is not the case.



FIGS. 8, 9, AND 10

A condition of the stability of a retaining wall is that it will not slide on its base; that is, the frictional resistance of the base will

be equal to or greater than the horizontal thrust of the retained earth :

$$\mu W \geq C \frac{w h^2}{2} \cos \psi,$$

where ψ is the angle of inclination of the resultant earth pressure P to the normal to the back of the wall (assumed vertical). Taking the factor of safety as 1, the above expression can be solved for the minimum value of W for the three theories mentioned. Another condition of stability is that the wall shall not overturn ; in other words, that the sum of the moments of all active forces about the toe of the wall must be zero or

$$W \cdot x = P \cdot r.$$

This means that at the factor of safety of 1 the resultant of all the forces passes through the toe of the wall.

The relative size and form of the theoretical walls corresponding to the three formulæ respectively are shown in Figs. 8, 9 and 10. Thus for the same conditions it is seen that the Rankine formula requires a wall about twice the weight of the others. This example forcibly illustrates the difference between Rankine's and the modern wedge theory analysis. In the latter allowance is made for the downward force of the vertical component of the inclined thrust on the back of the wall, which considerably assists stability. Practical examples are not lacking of walls which have stood for years without mishap which, analysed by the Rankine method, should have failed by overturning. The same walls, analysed by the wedge theory, are proved to be stable. In the above examples we have assumed a factor of safety of unity. If now it is assumed that the density of the material of the wall is twice that of the first assumption—that is, 2 W_1, 2 W_2 and 2 W_3 respectively—then the resultant of all the forces acting on the wall would be R_2, cutting the base just outside the middle third. Therefore the walls have now a factor of safety of 2 and it will be observed from the ground pressure diagrams that they all show a high compression at the toe and a tension at the heel.

Now, from a structural point of view a tension at the heel may be of little consequence (as, say, on rock), but as a ground pressure it simply does not and cannot exist. What it indicates is that a portion of the base of the wall is not doing its work and therefore a smaller width of base has to take a higher pressure to make up for it. This does not make sense. In poor ground a foundation so designed will assuredly give trouble ; there will be a tendency under even the slightest settlement to make still narrower the active base and in clays or soils of high moisture content there is also the variable vertical consolidation to contend with. The wide variation of the ground pressure under the base may give rise to a lateral flow, which will cause the wall to slide forward. It is for this reason that the author favours a factor of safety of not less than 2·2 for the base of a retaining wall on soil foundations to ensure compression over the whole base. The body of the wall, if of the gravity type, may, of course, be designed at a lesser factor of safety.

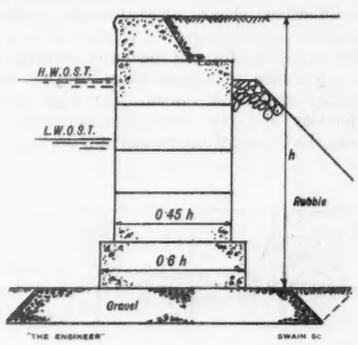


FIG. 11—QUAY WALL

If no test data are available the greatest care must be exercised in the selection of the coefficient of friction for any soil of a clayey nature. For soft clay it may be as low as 0·05 and for stiff clay 0·15 and for very stiff clay (dry) 0·28. Many designers are inclined to exaggerate the assistance of passive resistance of a soil to sliding. Passive resistance of the soil at the toe can only come into play when the wall has begun to fail by sliding and in the same way that there is a vertical consolidation under the base due to the active gravity force there is at the toe lateral consolidation due to the active force causing sliding. Consolidation requires movement, and before passive resistance can be fully mobilised the ground at the toe must be consolidated to the equilibrium density corresponding to the intensity of passive resistance at the toe. Simply stated, the author does not advise any allowance for passive resistance for foundations at moderate depth, and for deep foundations it should be borne in mind that failure is more likely to be due to tilting at the top and that a wall may heel forward 3 deg. or 4 deg. without any appreciable resistance from the ground at the toe. For many years the author has contended that the failure of a wall under the active force is brought about by the rupture of the retained earth well in advance of the mobilisation of the opposing force known as passive resistance, which in water-bearing strata may never materialise.

Quay or wharf walls abutting on tideless or tidal waters should never be designed with any allowance for toe resistance from the ground, no matter how deep the foundation is placed. Where the river or dock bed is of a moderately good material—sandy clay, sand or a stiff clay—it is good practice to excavate or dredge a trench and fill with gravel or small rubble, as in Fig. 11, which shows a sturdy easily built wall of pre-cast blocks. In this connection it is instructive to consider a form of ground which has by many failures registered on it proved to be troublesome to engineers. The wharf wall in Fig. 12 is shown founded on piles driven to rock through 30ft. of clay. There are three rows of piles ; the outside rows are at 2·0ft. centres and the middle row at 5ft. centres. The close piling of the outer rows converts the structure into a virtual retaining wall from rock level without the advantages

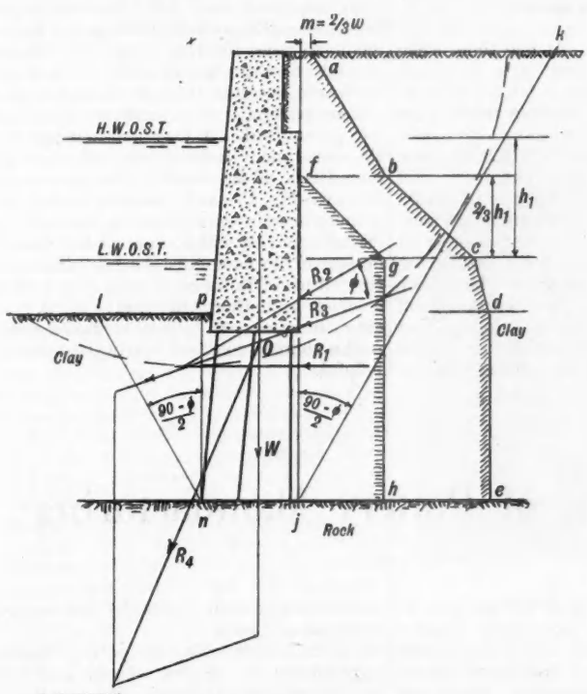


FIG. 12—WHARF WALL ON PILES

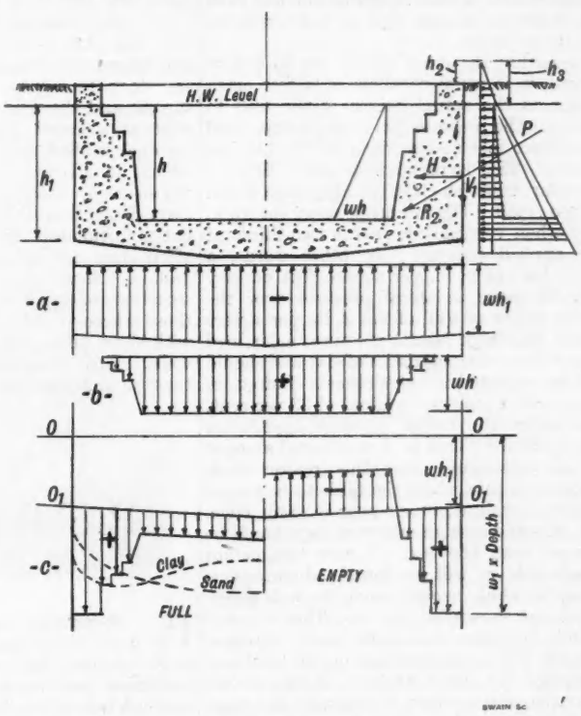


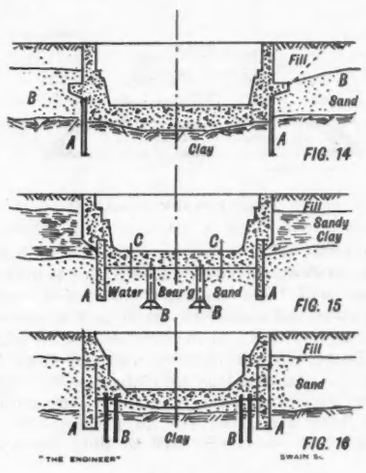
FIG. 13—CONSTRUCTION OF GRAVING DOCK

of a retaining wall. The diagrams show the distribution of pressures according to the wedge theory, part of the wall and fill being considered as waterborne. The diagram *f, g, h, j* shows the net water pressure at the back of the wall and the larger diagram *a, b, c, d, e, j* is the combined diagram of pressures due to load, fill and water. The resultant of the water pressure acting horizontally through the centroid of *f, g, h, j* is R_1 and the resultant of the load and fill acting on the back of the wall at the level of the centroid of the area *f, g, h, e, d, c, b, a* slopes at the angle ϕ to the normal to the back of the wall. The resultant of R_1 and R_2 is R_3, which acts slightly above the heel of the concrete wall and cuts the vertical through the centre of gravity of the virtual wall at O. W is the total weight of the wall and clay contained between the piles. The chief resultant of all the forces is R_4, cutting the base at rock level just outside the outer row of piles ; therefore at low water spring tides the structure has a factor of safety slightly less than 1. It will thus be noted that the whole of the weight and thrust is carried by the outer and middle rows of piles and the inner piles act only as tension members. The thrust on each of the outer piles is no less than 82 tons and there is a shear stress of 15 tons on all piles. Eventually the wall failed and travelled some 16ft. riverwards. This would have happened much earlier but for the tension taken by the piles at the heel. As it was, the piles sheared and the wall was pushed out. Had the structure been analysed as shown in Fig. 12 the failure would have been foreseen and a wall would have been designed with a base width of not less than one-third the height with a more rational pile distribution.

Regarding the super load on the fill behind a wall, it is usual to allow w_1/d feet extra height to the actual height of the wall to calculate the pressures, where w_1=super load per square foot and d=weight of cubic foot of fill. This is permissible where fills are granular, but with clays the allowance would be too small. The lateral pressure set up in clay when vertically loaded is two-thirds of the applied pressure ; in other words, a super load of w_1 lb. per square foot on clay fill will cause a lateral pressure over the entire height of wall of $2/3\ w_1$ lb. per square foot. This high lateral pressure under load is one of the characteristics of clay and should not be neglected in calculations. Indeed, in clays with a moisture content of 33 per cent. and above the lateral pressure approaches the hydraulic ; that is, it is of equal amount in all directions. For this reason it is imperative that where the fill is to be tipped behind a wall at, in, or near a water edge, any silt mud or high moisture clay should be cleared from the bed. Where this is not practicable it will be found advantageous to tip a rubble backfill from the wall shorewards, as shown in Fig. 11. This serves a double purpose ; the high angle of repose reduces the lateral pressure on the wall and increases the shear strength of the section near the wall at what is generally the most critical point. In addition, it squeezes the silt or mud away from the wall.

In harbours and rivers where there is a wide tidal range, quay and wharf walls founded on clay are subjected to a measurable tilting consequent on the elastic compression and expansion of the river bed under the variation of the hydrostatic head of high and low tides. This phenomenon in itself does not affect the stability of a wall providing the factor of safety is ample, but if, as many failures have indicated, the factor of safety is nearer 1 than 2, the regular periodic fluctuation may have a dangerous effect upon the incidence of the resultant pressure of the backfill. It is therefore of great importance to investigate thoroughly the characteristics of all clay foundations. A very slight tilting of a wall may for the nonce reduce the lateral pressure, but it tends to mobilise, perhaps at great disadvantage, the shear resistance of the fill. As the author has shown elsewhere, when the fill is saturated the effective shear resistance is greatly reduced.

The necessity for soil mechanic analysis is nowhere more necessary than in the construction of graving docks. The wide range of loading and the vessel-like construction render the foundation treatment a problem of



FIGS. 14, 15, AND 16

paramount importance. At one time, when the dock is empty, there is a buoyancy surplus and the tendency is for the dock to float as a vessel ; at another time, when the dock is filled, there is a heavy load placed on the foundations—see Fig. 13. On good foundations, such as rock and very stiff clay, little trouble need be apprehended ; but unfortunately, these structures are more often than not situated on the poorest of ground. Some of the most successful constructions of docks in poor ground have been those where the site has been curtained off with sheet piling, concrete walls or cylinder walls. This curtain wall not only facilitates construction, but serves the excellent purpose of lowering the effective seat of foundation pressures, preventing quicksand effects and, where it is tied into the main body, it provides a substantial auxiliary to the deadweight to counteract hydrostatic uplift. In Figs. 14, 15 and 16 three different methods of attaining the same object are shown. Fig. 14 is founded on clay and has a sheet piling wall A and a concrete shelf B to assist the deadweight to counteract the uplift from the water-bearing sand overlying the clay. The section of Fig. 15 is founded on water-bearing sand with a quicksand effect ; that is, subject to hydraulic gradient, and the foundations are curtained off with a reinforced concrete wall A. Concrete anchor cylinders B are sunk below the floor to withstand the uplift and drainage relief holes are formed in the floor at C. Note that the side walls are overhung to oppose the side thrust of the retained earth and water pressure. In Fig. 16 the section shown is that designed for a narrow bed of sand underlaid by a deep bed of stiff clay. The curtain wall A is formed by sinking cylinders of about 6ft. diameter separated only by a timber sealing pile. The piles B are novel, insomuch that they are placed as though at the toe of a retaining wall to withstand the toe pressure and so reduce the reverse bending moment in the floor slab. The most severe loads occur on the sub-foundations when the dock is full—see *c*, Fig. 13, which shows the combined pressure diagram for the deadweight of the dock, the contained water and the hydrostatic uplift. Where the floor is pierced by drainage holes the hydrostatic uplift is reduced and consequently the ground loads are greater. Now, as the dock floor is usually extremely thick and rigid, there is no give in the foundations and therefore no adjustment to the reacting behaviour of the ground ; in clays this takes the form of consolidation, vertical and lateral, and in sand a disinclination at the boundaries of pressure to oppose load. A clay sub-foundation is therefore more heavily stressed near the boundaries of the loaded area—see dotted line in *c*, Fig. 13—and a sand sub-foundation is more heavily stressed at the centre of the loaded area. It will be appreciated that the design of the floor must be co-ordinated to the nature of the ground, and this involves a close and thorough study of the soil characteristics and behaviour under stress ; in this connection direct bearing tests are not helpful.

Problems of Pottery Manufacturing

IT is sometimes claimed by disciples of William Morris that the pottery industry in Britain remains a craft true to its peasant traditions, and that the industrial revolution has had but little effect on the "placid and uneventful" lives of the potters of North Staffordshire. It is true that the Potteries' skyline is still crowded with the smoking stacks of the familiar, bottle-neck ovens and kilns, and that in many factories the thrower's wheel is still in operation. It is true also that the ingredients used in the manufacture of earthenware and china and the products themselves, tablewares, and decoration pieces, are very much the same as they were in the days of Josiah Wedgwood. It is only when processes are considered and output figures are checked that one is able to realise the great changes brought about in the industry in recent years by the ceramic chemists and engineers.

The task confronting the pottery engineer is primarily the efficient, speedy, and exact reproduction of standard designs and models. This is an aim common in all light industries, but in potting there are peculiar difficulties. In the first place, there are strict limits to the degree of standardisation which can be adopted. Pottery is a semi-luxury trade in which variety is the keynote of public demand. Where small orders are the rule and a multiplicity of designs must be stocked, expensive and inadaptable plant is out of the question. It follows that the making processes in potting are unlikely to become completely mechanised. Again, the "body" of earthenware and china must be passed through fire before becoming durable and

serviceable. This additional, but essential operation has a modifying influence on processes. The problems of firing are now in process of solution.

It is intended here to deal only with those aspects of the industry in which the science of engineering may be said to hold the key to further progress.

When pottery materials (china clay, Cornish stone, calcined flint, and ball clay for ordinary earthenware) have been finely levigated and mixed with water, a "slip" is formed. It is sometimes found that the slip contains minute particles of iron, which have found their way into the raw materials during preparatory handling and grinding. Calcined bone (used in the manufacture of china) and flint are persistent offenders in this respect. If the iron is allowed to remain in the body composition it causes unsightly black specks in tableware and reduces the dielectric strength of porcelain insulators. Black marks in pottery are usually attributable to pure iron, yellow and brown specks being caused by the presence of pyrites and iron sulphide particles.

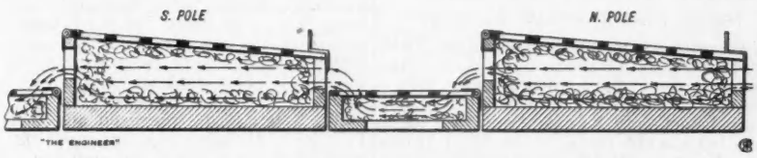


FIG. 1—FLOW OF "SLIP" THROUGH INCLINED TROUGHS OF MAGNETIC PERCOLATOR

In early days permanent magnets were used to extract objectionable iron. Horseshoe magnets were fitted into inclined troughs so that the slip flowed against them and was magnetically "sieved." However, the magnets were of such low intensity that they were incapable of eliminating any but the larger iron particles. By such methods it was impossible to remove the particles of iron sulphide and pyrites, since they are only feebly magnetic. Developments in electro-magnetism have produced high intensity separators capable of extracting practically all ferrous bodies, so that speckled ware is now extremely rare. One successful type of separator contains a series of magnet bars, each a separate casting, powered from enclosed magnet units. Each bar impedes the flow of the slip by its staggered projections. By this device frictional contact is maximised so that the holding capacity of the bars is improved. The inclination of the trough depends on the density of the slip. A slope of 1 in 4 is capable of treating 2¼ cwt. of slip (26 oz. to the pint) per inch of width in one hour. The magnetting of 1 ton of slip costs about 1d. for power. In the event of current failure collapsible bridges, operated electro-magnetically, divert the slip, so that it does not mix with that already treated.

A new principle in magnetting (incorporated in the new "Rapid" magnetic percolator—a product of the Rapid Magnetting Company, Ltd.) is the supersession of projections and serrations by detachable box-frames containing numerous pieces of perforated metal. These are fitted over each magnet bar and intermediary between each pair of magnets. The bottom of the trough is thus filled with a mass of magnetic edges forming a "magnetic grid" through which the liquid must percolate. Slip flows through the succession of percolators being forced to climb, before egress, over the dam-like obstructions—Figs. 1 and 2. This device checks the flow so that it may receive a thorough searching for metallic particles. Should the first grids become choked with particles the slip is not held up, but circumvents the obstacle, flowing over it. It is claimed that a ten-magnet percolator, 24in. wide and consuming 1200 watts of current, can handle 4–6 tons of slip per hour.

The vast majority of tablewares, cups, saucers, plates, &c., are now fashioned by semi-mechanical power-driven apparatus. "Jolleys" (for cups) and "Jiggers" are the trade names for such machines.

The jigger consists of an upright spindle, geared to revolve at required speeds, covered with a brass or gunmetal head shaped to fit the plaster mould which it must carry. In line with the jigger there is a fixed, balanced standard carrying the profile of the plate. When operated by hand, the profile arm descends through an arc and comes in contact with the bat of clay which has been placed on the revolving mould. The profile thus shapes the underside surface and the mould impresses the form of the inside of the dish. When the operation is completed, the moulds bearing the shaped clayware are placed in a drying chamber. The clay frees itself from the mould by contraction, and is ready for the next process. With careful treatment a saucer mould will produce as many as a thousand pieces of ware. The jolley works on the same principle, with the exception that the operations of the profile arm and mould are reversed—Fig. 3. The cup mould

FIG. 2—MAGNETIC PERCOLATOR

gives the exterior form and the profile tool shapes the inside of the vessel. Jolleying and jiggering are speedy processes. A plate-maker, making 7in. trade plates, can produce 80–120 dozen per day, or 150 per hour. Cup-makers may make as many as 200 dozen per day, or 300 per hour.

Recent progress in the technique of glazed tiles manufacture suggests that the making processes in tableware production may eventually be revolutionised. Glazed tiles are simple in form and require very little handling. They are now made by the dust-pressing process, which, with suitable, modifications, might well be found practicable for the production of ordinary earthenware and china. The clay body is reduced to a finely divided powder, which is subjected to great pressure (as much as 12 tons to a 6in. by 6in. tile) between the steel dies of tile presses. This method of moulding utilises pressure to cause adequate interlocking of the dust grains, for the clay has no adhesive quality other than the colloidal properties of a small quantity of water. The clay must contain sufficient flux to bind the particles together when heated in the kiln. Except in the manufacturing of special shapes, the pressing operation is performed at room temperature. For intricate designs, the dies may be steam-heated. It should be noted that the moisture content (8–10 per cent.) is usually added by spray to dust which has been dried thoroughly. It has not been found practicable to reduce the humidity of ground clay to the required figure by drying processes.

Girls operate the pressing machines, sweeping the dust into the boxes and manipulating the weighted top die with dexterity. A good presser is able to produce 250–300 dozen tiles per day. Formerly belt-driven presses were common, 6 H.P. being necessary to drive four machines. There is a considerable saving of power, and stoppages are minimised through the more recent employment of independent 1 H.P. motors. So far, the successful production of tablewares by dust pressing has defied the efforts of the ceramic engineer. The principal difficulties are the friable nature (before firing) of the pressed wares, causing spoilage in subsequent handling and the low tensile strength of the fired product in view of the necessary thinness of tableware.

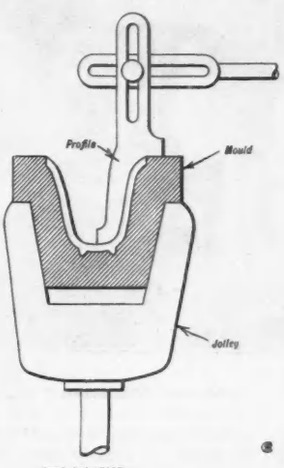


FIG. 3—ARRANGEMENT OF "JOLLEY"

Perhaps the most interesting of all recent developments in potting is concerned with firing. The North Staffordshire region has persisted in its choice of the intermittent coal-fired oven long after the economies of the continuous tunnel oven have been demonstrated on the Continent and in the United States. This is, in part, due to the excellent fuelling facilities which the Potteries district enjoys, by reason of its situation on the North Staffordshire coalfield. Coals of particularly suitable type, of long-flame quality and high calorific value, are available. Within the last decade, however, the installation of tunnel ovens has been widespread. Typical of the recent trend is the new Wedgwood factory at Barlaston, where the firing of both biscuit and glost ware is electrical. The kiln is a two-way tunnel through which rail trucks move at regulated speed. In the firing zone a temperature of 1200 deg.

Cent. is attained. It is significant that this kiln is the first electrical installation in Britain to fire at this temperature. The tunnel is provided with special roofing to facilitate the extraction and replacement of failing heating elements and the jambing of trolley cars can be corrected from a passage which runs beneath the tunnel.

One of the chief problems of the electric kiln engineer concerns the construction and arrangement of efficient heating elements. The difficulty of obtaining resistors of an economic durability held up the progress of electrical firing in its early days. It may be said, however, that for most temperatures, satisfactory elements are now available. For temperatures up to 1200 deg. Cent. the nickel-chrome alloy, nichrome, and the iron-aluminium alloy, kanthol, have been proved effective element metals. In furnaces operating at higher temperatures, composite resistors, known as Globar or Silit resistors, and containing carborundum and fire-clay, are used. Arrangement of these elements in the furnace depends on the design of the furnace. The Globar or Silit resistors take

FIG. 4—"JOLLEYING"

the form of rods stretching across the interior surface; nichrome is usually in the form of strips or coils set in channels in refractory walls.

When it is recalled that the tunnel oven may require a linear accommodation of 100 yards (the Wedgwood oven is 273ft. long), that tunnel equipment is expensive, and that the small firm is typical in the pottery industry, it will be realised that many manufacturers are compelled to continue firing by the relatively inefficient intermittent ovens. The waste inherent in the intermittent ovens is revealed by the generalised figures of its heat balance:—Heat in ware, 2 per cent.; heat in saggars, 10 per cent.; waste gases, 52 per cent.; heat lost in brickwork and by radiation, 36 per cent. In addition, the necessity of allowing the oven to cool before restacking increases the duration of the cycle of operations, Tunnel ovens are continuous, and must be kept fully charged with ware. Where trade is sporadic the tunnel oven is more of a liability than an asset.

Town gas has been favoured by most potters as the ideal fuel for tunnel firing, by reason of its unvarying combustion qualities, by the reliability of its heating appliances, and by its relative cheapness per thermal unit. Producer gas has not been so successful. The high initial cost of plant, the need for an alternative supply in case of breakdown, the disposal of waste products, the deleterious accumulation of tar and ash in feeder pipes and the instability of the combustion qualities of the gas, have caused most manufacturers to rely on mains supply. On the other hand, there are conspicuous examples of the successful utilisation of producer gas. One factory, consuming 9 million cubic feet of gas per week in its two large tunnel ovens, has solved the problem of tar removal by electro-static precipitation. Its gas is clean and dry, and large quantities of tar are recovered and marketed.

South Africa's War Effort

(By Our South African Correspondent)

Two years of war activity have driven South Africa's industrial advancement far ahead of the position it would have reached under normal peacetime conditions. The country is now able to supply not only its own Army with all it needs, but it is able to ship to the Allied Armies in the North and Middle East great quantities and varieties of manufactures and spares.

When South Africa faced the urgent need for reorganising her industries to achieve the greatest possible output in the shortest time when war broke out, it was common knowledge that the military supplies cupboard was bare. There were no reserve stocks of uniforms or equipment nor, indeed, any prepared plan for obtaining them. In the munitions and armament field a little work had been done in the production of field mortars, one experimental howitzer had been constructed and there was a plant—that of the Royal Mint on the Rand—capable of producing 10,000,000 rounds of 0·303 rifle ammunition per annum. To-day a large mechanised army has been placed in the field and supplied through a fast and vigorous campaign. South African made guns are flowing off a production line which was not even on paper about fifteen months ago. Tens of thousands of bombs have been produced and shells, grenades and many other types of munitions.

The South African boot and shoe industry was speedily called upon, for the Army had to be quickly shod. Actually the capacity of the industry in machines and operatives was far in excess of the Army's demands, but it consisted of separate units, which knew little of co-operative effort. When particulars of these requirements were furnished the Army boot specification was drawn up and a South African type evolved, and very soon the factories were delivering the goods by the thousand. They caught up with the demand, then exceeded it, and finally were able to accept large orders for other units of the Allied Armies. At present they are engaged on orders for hundreds of thousands of pairs. The total annual production of all kinds of footwear in South Africa is now between 7,000,000 and 8,000,000 pairs.

Blankets were another urgent need of the growing Army. South African wool went into the looms and the flow began. A high standard is demanded, and South Africa has reaped the benefit of its early war production experience by being called on to fill large orders for the Middle East. The call for uniforms for the tens of thousands of men who joined up gave the clothing industry also a chance to demonstrate its ability to drop speedily into mass production, not of one type of military dress only, but of a surprisingly large variety. South Africa has no mills from which to draw stocks of cloth, but already one for the manufacturing of khaki drill has been set up and may lead the way along a new avenue of industrial development. Young and as yet small industries in an associated field have also been given a chance. Canvas and webbing are now woven in great quantities, and leather goods, which previously were all imported, are now coming from South African benches.

Canned Food for the Troops

Even in the days before the war the South African food canning industry, fairly well established and organised, was well on the upgrade, and the war immensely stimulated the demand, increasing the call for existing lines as well as encouraging the development of new types. Among new products not previously canned in the Union on a commercial scale is the important Army meat and vegetable ration. Certain canneries in the Union are specialising in this production, which consists of meat, peas, carrots, beans and onions, all in one can. Other canneries are specialising in the production of mixed vegetables, and the result compares favourably with anything produced in the world to-day. A tin of mixed vegetables may contain potatoes, carrots, peas and beans, with turnips, onions and celery used as flavouring. Sweet corn is also being canned on the Rand in considerable quantities. Sausages, too, are being canned for the Defence Force in quantities which before the war would have seemed enormous. Even dried fruits are now being put up in cans, the chief lines being prunes, raisins and apricots. The canning of butter and wholesome pasteurised cheese for the troops is also being undertaken with great success by various creameries in the Free State, Natal, East Griqualand and the Cape Province. Alongside this important development, large quantities of fruit and jam—plum, peach, fig, apricot, pineapple, and gooseberry—are being canned, not only for home consumption, but also for South African troops and for export to the United Kingdom.

Full utilisation of the food resources of the sea have never previously been attempted by the Union, but now the resources of the fish canning industry in the Union have been drawn upon very heavily to supply defence requirements. Each small tin—whether its contents be fish paste, balls, cakes or flakes, or fried fish in mustard sauce—represents an easily transported, always safe and appetising quantity of food which adds both nutrition value and palate appeal to the ordinary rations issue.

The Department of Defence has also decided that canned snoek, canned pilchards and canned mackerel will be admirable for the Union troops. This will be the first attempt to can any of these fish on a large scale. Before the war large quantities of crayfish were canned and exported mainly to France, but France collapsed and now Great Britain is buying virtually the whole of the South African crayfish pack.

Engineering Resources

But it may confidently be said that in the engineering field South Africa has received the greatest benefit from the war. South Africa has one major asset, the value of which cannot be overstated—its established steel works. When the Great War was waged twenty-five years ago they did not exist; to-day they are producing over 400,000 tons of steel annually, and are still being expanded. Without them South Africa's munitions and armaments production would have been a mere trickle. With the steel available it was possible to take advantage of the existing engineering resources of the country. These were not, however, production resources in the true sense, in as much as they consisted of the repair and maintenance shops of the railways and municipalities and the engineering shops which have grown up around the mining industry, as well, of course, as the marine engineering shops at the coastal towns. The latter, however, are playing a very important part in their own sphere and have been too busy on the repairing of damaged ships to enter into the munitions and armaments programme. Moreover, war conditions demanded deliveries in vast quantities, and the immediate problem was to adapt the existing plants to the new needs of mass production.

In this respect the difficulties went deep indeed, but first showed themselves in the lack of machine tools and skilled workers. The former position is improving as the result of importations, and also by reason of ingenious adaptations of machines and even the manufacture in considerable quantities of single-purpose lathes in this country. The lack of skilled men, however, is still very much felt and has been complicated by the need for skilled artisans in the Technical Services and the Air

Force. Nevertheless, the engineering industry has forged ahead and production has increased to a *tempo* which would have been thought impossible two years ago.

GUN PRODUCTION

There are many specialised developments aimed essentially at war production, but these nevertheless will have a far more lasting benefit than merely meeting a transitory demand. One is gun production. This has called not only for an elaborate equipment of machinery, but for special steels, for highly skilled precision work and the building up of a central assembly factory. The steel works met the call for the new steel and after research built a heat treatment plant—ovens, quenching pits, &c.—and had it in operation in six weeks. The production of the component parts of the gun has been spread out over a large number of workshops, and thus the experience gained is not confined to any one branch of the industry nor to any one centre. Wherever suitable workshops existed or could be built up from machines already available, there the work has been sent. The components flow to one central ordnance factory, where the major work on the barrels is done. There the assembly takes place, and there, too, are manufactured the sights for the guns. On the "repetition tasks" women are proving excellent workers and a large staff of skilled machinists is benefiting from intensive training and experience in the work.

SHELL PRODUCTION

Shell manufacture demands mass production. At first plant could not be imported from overseas, except at great expense of time, and so it was decided to build it in South Africa. Bigger castings than had ever been made in the country were successfully turned out and on the scheduled day the plant went into action. Its output has steadily risen and a "bottle neck" in finishing the shell bodies has been overcome by the production in the country of large quantities of single-purpose lathes, most of which are operated by women.

ARMOURED CARS AND VEHICLES

One of the greatest achievements has been the mass production of armoured cars and vehicles for the mechanised army. The motor-car industry, which has its headquarters at Port Elizabeth, is now ranked as the Union's most important industry. Certainly its most outstanding achievement, in co-operation with the country's leading engineers and technicians, has been the production of great quantities of armoured cars. The only imported parts of the cars are the chassis and engine. The framing, plating, turret building and final equipping of the car is entirely from South African resources, and a first-class job has resulted, one which has earned the praise of the Imperial Army commanders in the East African campaign.

MECHANISING THE ARMIES

But a far more extensive production programme was called for in the mechanisation of the Army. No fewer than sixty-five types of vehicles are demanded, some in relatively small numbers, but others in great quantity. Once again the work was spread over the workshops of the country, and on the chassis that came from overseas were built a great variety of bodies—for troop carriers, mobile workshops, staff cars, light aid vans, radio vans, ambulances, oil tanks to supply other vehicles with petrol and oils, large trucks for the engineers, road construction trucks, scores of specially fitted ambulances, special trucks to carry artillery units and ammunition, besides other models used to carry out the various duties a modern army is called on to perform. Provision has been made for every conceivable contingency in motor transport.

One of the "high lights" of munitions production in South Africa is the manufacture of howitzer guns. On February 16th, 1941, the first battery of howitzer guns to be manufactured in South Africa was officially handed over to the Defence Department. Every component of the guns had been produced in South Africa, including the sights. Yet on June 1st, 1940, there was not a machine tool in the Central Ordnance Factory, where these guns are now being turned out on mass production lines. It has been stated that this is probably the first time in history that the mass production stage of a new gun has been reached in nine months. Again heavy firing power combined with portability render field mortars a type of artillery specially suitable for African conditions and these weapons are being produced in great quantities. Very special problems were presented in the design and manufacture of the sights, both on account of the fine limits of accuracy required and of the large numbers of small and intricate components. Nevertheless, a Transvaal concern, specialising in high-precision work is producing sights which, it is believed, contain various improvements not yet adopted by munitions factories overseas. So good is the job that the British Government has placed with South Africa a large order for these sights. South African firms are manufacturing field mortar bombs by processes which they have evolved themselves with no advice from overseas experts and with no details of the processes used in British or American factories to guide them. Almost from the very beginning of the war the production of heavy aircraft bombs has been in full swing.

From the long list of articles now being made for use on the war fronts may be mentioned at random hand grenades, Bellman hangars, portable bridges, gun aiming posts, air raid sirens, steam-heated cooking troughs and water carriers.

SHADOW FACTORIES

To appreciate the extent to which the Union's engineering industry as a whole is collaborating in the production of munitions it has to be realised that such articles as howitzers or armoured cars or to a lesser extent bombs, shells and depth charges contain many components and these are produced in "shadow factories" throughout the country. For example, the number of workshops which have collaborated in the production of the bombs dropped by airmen on Tripoli and Benghazi is considerable. Other firms have co-operated by manufacturing jigs, tools, gauges or machines for munitions production. Thus one Rand concern has built, *inter alia*, a bullet piercing and a bullet assembly machine, while another has made a number of lathes and is producing machines of various types for foundry work. A firm of specialists has designed and made special machines to produce small springs and spring washers, required in large quantities by the Director-General of War Supplies.

All the switchgear for the shell plant was made in South Africa from imported components, while several of the transformers were also locally manufactured. Among other products of electrical engineering workshops are spot welders, arc welders, D.C. generators, induction motors, and oil-cooled metal-clad reactors for arc furnace control.

In conclusion, it may be asserted confidently that the biggest factor in enabling the secondary industries in South Africa to expand rapidly and meet the heavy dmands, not only to increase production, but to cope successfully with the calls for entirely new manufactures has been the efficient generation and the economical distribution and utilisation of electric power.

American Engineering News

Training in American Factories

With the great increase in the demand for men in manufacturing industries on account of the vast programme for national defence production, and the great decrease in the number of men available, due to the draft for military service, these industries in the United States are faced with a serious situation. A recent report of the Westinghouse Electric and Manufacturing Company shows that since the summer of 1940 it has added 20,000 new employees to its forces, and has now a total of approximately 71,000. In one day the applicants for employment may number 500 to 600. When production began to increase with the defence programme, former employees were recalled, skilled men were employed wherever found, and enrolment was increased in the apprenticeship and short-term training courses in the company's various works. By the summer of 1940 enrolment in the three-year and four-year apprenticeship courses was more than doubled, in order to provide machinists, tool makers, patternmakers, and die makers. At one of the largest works, enrolment in the two-year shop courses was trebled, training high-school graduates as operators of one or two types of machine tools, and also as sheet metal workers, assemblers and apparatus wiremen. At another plant 1000 young men were put into a ten-month course in machine operation. They spend some hours a week under trained instructors, and about thirty-six hours in producing motor bearings and frames under the guidance of experienced craftsmen. Another source of supply is the advancing of men handling simple automatic machine operations to the operating of more complex machines. To meet a serious shortage in the drawing-office force, some of the best youths in high-school mechanical drawing classes are taken and trained as junior draughtsmen. The 20,000 new employees include 3000 women, bringing the total to 12,500, nearly 9000 of whom are production workers.

American Steel and Coal Situation

With declining consumption of coal in relation to the tonnage production of both pig iron and steel, due to improved methods of manufacture, the coal industry of the United States is being warned to undertake a definite study as to improvements in coal production and developments in new uses of coal. Thus the amount of coke consumed per long ton of pig iron declined from 2375 lb. in 1918 to 2017 lb. in 1938. And one steel works that used 1260 lb. of gas coal per ton of ingots reduced it to 137 lb. in 1939. With producer gas, the open-hearth furnaces were the largest consumers of this coal, and its replacement with fuel oil was a large feature in the decreased demand. Again, there is increased use of scrap metal in steel production, and this material is fed to open-hearth furnaces heated by fuel oil or gas. This means a decrease in iron ore and a corresponding decrease in coke for the blast-furnace. The coal industry is said to have been lacking in initiative as to means of combating this condition, and to have given its main attention to producing coal that will make a coke satisfactory for blast-furnace use. On the other hand, some steel works have developed special uses for coal. First, pulverised coal with blast-furnace gas for boilers; secondly, pulverised coal for open-hearth furnaces; thirdly, smelting iron ore with coke breeze; and fourthly, direct reduction of magnetic iron ore with activated carbon. Steel works with blast-furnaces and coke ovens have a supply of gas at hand, the oven gas serving to enrich the furnace gas. There are possibilities in the gas producer working on solid fuel, and in the so-called colloidal fuel of pulverised coal mixed with oil. It may be many years before such developments reach the practical or commercial stage, but should there come a shortage in the supply of petroleum and natural gas, as has often been predicted, there would be a great impetus to the development of coal utilisation.

CLAD-STEEL PRESSURE VESSELS.—The Boiler Code Committee of the American Society of Mechanical Engineers has approved integral-bonded alloy steel lined plate for use in the construction of fusion-welded unfired pressure vessels. The ruling covers permission for the use as liner materials of nine of the standard corrosion-resisting chromium and nickel-chromium steels. Simultaneously, the Committee has removed certain restrictions hitherto ruling and the effect of the modifications is to give manufacturers of pressure vessels wider discretion in selecting types of cladding best suited for use in contact with specific corrosives, and a larger choice of backing materials to meet design strength requirements.

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EIGHT-PAGE SUPPLEMENT—"THE METALLURGIST"

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The Metallurgist.

THE DECEMBER NUMBER OF THE METALLURGICAL SUPPLEMENT TO "THE ENGINEER" ACCOMPANIES THIS ISSUE

STEAM LOCOMOTIVE BALANCING

THE extraordinary complexity of the reasons for, and effects of, locomotive balancing were scarcely realised before the investigations made by the Bridge Stress Committee thirteen to fifteen years ago. Indeed, since the general principles on which balancing should be accomplished were enunciated by Le Chatelier and D. K. Clark in the period 1849–55 until the Committee's report of 1928, the only contribution of any merit to balancing practice was W. E. Dalby's graphic solution. For the six-wheel engines of his day, D. K. Clark recommended that two-thirds of the reciprocating weights should be balanced by revolving counterweights in the wheels, and without any thought as to what this figure actually represented succeeding generations of engineers used it until the report of the Bridge Stress Committee thoroughly analysed all the vertical forces, and even now it is found in certain designs of large size. Yet, in general, the large moment of inertia of modern locomotives makes unnecessary the balancing of anything like such a large proportion of the reciprocating weights. An almost subconscious realisation that good balance was linked up with engine size was shown by the Master Mechanics' Association in the U.S.A., which from the late years of last century has (with its successor, the Mechanical Division of the A.A.R.) recommended that the proportion of weight to be balanced should be limited to a specific fraction of the total engine weight. With the increasing size of locomotives, limitation of the hammer blow became urgent in order to keep rail stresses and bridge impact values within bounds, and as a result a practice grew up, particularly on the Continent, of fixing the maximum hammer blow at a given speed in terms of the static weight on the wheels, and from that point working backwards to decide what fraction of the reciprocating weights had to be balanced. With large engines this usually meant 15 to 40 per cent. of reciprocating balance, a range which was quite common in Europe, and in Japan, ten years ago. The Bridge Stress Committee's report was invaluable for the way in which it drew attention to the existence of hammer blow per wheel, per axle, and per locomotive, and to the reason why locomotives which were good performers in one respect were often bad in another. British balancing improved out of all knowledge after 1928, and the majority of express engines designed since that date have hammer blows a good deal less than the Committee's recommendations of 5 tons per axle (or 25 per cent. of the axle load) and 12½ tons per locomotive as the maxima at 5 r.p.s.

The next step was to try and eliminate hammer blow by leaving the reciprocating parts quite unbalanced, and it is to the feasibility of this method that the Colam-Watson and Cox papers, abstracted elsewhere in this issue, are directed. They provide a fruitful field for discussion, for the principal conclusion of the first paper is that elimination of hammer blow is perfectly practicable, whereas Mr. Cox considers that heavy two-cylinder engines do require a fair amount of reciprocating balance to reduce the longitudinal oscillations of the locomotive. He agrees, however, that as three and four-cylinder locomotives are balanced as to longitudinal forces they do not require reciprocating balance, a contention which is supported as to the second part by the excellent riding of the "Merchant Navy" "Pacifics" and one of the "Schools" 4–4–0s on the Southern Railway. But the Indian experience on which Messrs. Colam and Watson base their recommendations was obtained with two-cylinder broad-gauge "Pacific" engines, a type which, according to Mr. Cox's reasoning, ought to have reciprocating balance to the extent of at least 40 per cent. Probably the fact that the two opinions are opposite may be traced to the different speeds, for the service speeds in India rarely rise much above 60 m.p.h., whereas on the L.M.S.R. pre-war speeds of 90 m.p.h. were common. Mr. Cox went to some pains to show how rapidly the effect of unbalanced forces rises with increasing speed, until a fluctuation of the order of 38 tons in the theoretical draw-bar pull during one revolution is attained at 90 m.p.h., with a 4–6–0 engine, the effect of lack of balance far outweighing the variation in torque from the steam pressure. Although Messrs. Colam and Watson recognise this effect, it is possible that the draw-bar springs may have had quite different characteristics, and in the Indian example may have had enough damping capacity to absorb much of the theoretical effect of the fore-and-aft movement.

One further complexity arising from modern operating speeds is that of wheel bounce. With any given overbalance it is easy to calculate the speed at which the wheels should lift from the rails due to centrifugal force and in one investigation we made this speed was found to be about 88 m.p.h. for a 4–8–0 engine with 55in. wheels and 66 per cent. reciprocating balance. As a rule these lifting speeds are far above the operating rates for the particular engine, but in several instances lifting has occurred at speeds considerably lower than the calculated value, and this appears to be due to forced vibrations in the wheel and axle assembly resulting from unbalanced forces, the bouncing up and down being due to this and not to resonance between engine and track. Mr. Cox referred to L.M.S.R. slow-motion photographic research which showed a lift of over 2in. at an equivalent speed of 104 m.p.h. with an overbalance of two-thirds in a 4–6–0 engine. The bouncing is a function of the hammer blow and forms a final reason why the balancing of reciprocating weights should be reduced as far as is possible consistent with a tolerable standard of riding as governed by oscillations arising from the driving mechanism.

The Supercharging of Engines

THE demands made on the aircraft designer steadily increase. One day it is for still greater range, on another for higher speed, and almost all the time for the highest possible height of operation. Although much can be done by improved materials of construction, much by sheer ingenuity of design, the supremely powerful factor is increase in the engine output at all heights to the greatest at which flight is possible. By making special efforts in refinements of design, including the use of two superchargers in series, an aeroplane was flown as high as 54,000ft. in 1937 (in Britain), whilst another attained 56,000ft. a year later (in Italy). So far as published information goes no aircraft has flown any higher since. To add to the stature of flight becomes increasingly difficult, every thousand feet costing substantially more than the last. The reason for this is that oxygen is just as much engine fuel as is petrol, and that although the latter can be carried in containers to just wherever

one wants it, the oxygen has to be taken in from the surrounding atmosphere, however tenuous that mixture of gases may become. At 20,000ft. the air density has but one-half its sea level value, so that during the engine induction stroke only half the necessary oxygen would be drawn in. At 40,000 the proportion falls to a quarter of the ground level figure, at 60,000ft. to one-tenth, whilst by the time—if ever—80,000ft. is attained it becomes but one one-thirtieth. At the last great height an unsupercharged cylinder would lack no less than 97 per cent. of the oxygen it would have taken in at sea level.

To meet this severe situation there are two equally obvious courses: one is to fit supercharging pumps despite the increase of weight, and the other is to make the cylinders much larger, also involving added weight. The relative merits of superchargers and over-sized cylinders were explored very carefully many years ago and the advantage was found to lie with the supercharger. The naturally aspirated over-sized cylinder needed to be so very large to deal with even moderate altitudes that its weight, if designed to operate at considerable heights, would be quite excessive. Hence the remedy universally used is supercharging, commonly by geared pumps for the first stage and often by an exhaust turbine for the second. An exceedingly attractive feature of the second-named plan is that the greater the height the less the back pressure (the turbine exhausting straight into the atmosphere) and the greater the power output, which is precisely what is sought. There is, of course, a limit to the desirable degree of supercharging, for if more and more pumps be added the additional weight must in the end overbalance any gain in altitude. Perhaps it is worth remembering also that if stratosphere flying becomes common passengers and crews will have to accustom themselves to a sort of personal supercharging, since human bodies need oxygen as well as engines and need the same special steps to attain it. The amount of extra air required in the cabin may be only a small fraction of that needed by the engines, but it calls for more attention in respect of quality, since oil mist is reputed to be a potent emetic.

This means of creating an artificial atmosphere in the engine cylinder, whenever high flying is required, suggests at once the question of the desirability of its use even when operating at sea level, so making use of a super-atmosphere. Through some millions of years the animal body has accustomed itself to an atmospheric pressure of some 15 lb. per square inch, and it does not react at all favourably to any large variations from that value. But from the point of view of the internal combustion engine—if it be conceived as having one—there is no special virtue in an induction pressure of this particular amount, and it becomes a nice problem to decide just what atmospheric pressure would most facilitate the working of such engines. One result of such an investigation is seen in the practice of the "ground boosting" of aero-engines—as it is termed—to much above the ordinary atmospheric pressure. This is now common, although owing to the immense access of horsepower so attained the unavoidable heat losses rise to an embarrassing degree of intensity, and this limits the length of time for which such boosting can normally be permitted. It follows that any modern efficient supercharged aero-engine can develop at will, for short periods of time at least, power much above its rated value, whether operating at ground level or at fighting altitudes. Such special efforts could continue for longer periods, perhaps even indefinitely, if the cooling of the engine could be suitably intensified. How far progress on such lines may have already proved to be attainable in the war weapons of to-day is not disclosed, but one can be confident that the results of the current war effort will be found to have peacetime applications, and that the post-war internal combustion engine will benefit not a little from the determined work on engine supercharging during the war years. The story of the relationship of the world's atmosphere to world history has yet to be written. All we need say here on this attractive subject is that, had the earth possessed but half its present atmosphere, the activity of engineers might soon have brought their engines up to full power, although they could not have overcome the consequent lowering of the lift of the wings of their aircraft with the striking consequence that the discovery of human flight would have been postponed for at least a hundred years—a delay which to some of us could have been easily borne.

Literature

Cofferdams. By LAZARUS WHITE and EDMUND ASTLEY PRENTIS. London: Oxford University Press (Humphrey Milford). Price 30s. net.

THIS book is a monograph, based on the authors' experience of six years as contractors for a number of dams and locks on the river Mississippi between St. Louis and St. Paul, each of which has involved the construction of at least three large cofferdams. The authors observe in their preface that the failures, difficulties, and narrow escapes, as well as the successes, have taught them much. The genesis of the book was not, however, in experience only, for the contractors' engineers, to whom the designing was largely entrusted, obtained the co-operation of the laboratories of three universities. The result is a work of distinct merit, which bridges the gap between the careful designing of important cofferdam works by consulting engineers and that large part of contractors' cofferdam practice which is either somewhat wastefully efficient or marked by untoward incidents and more or less costly delays.

The subject is introduced with a 43-page study of the hydrodynamics of cofferdams, beginning with the results of D'Arcy's basic work on the mechanics of the flow of water through porous media in 1856, and pursuing the subject to the work of later investigators, which included studies of the behaviour of silts and sands under various conditions of flow and turbulence. The subject of flow and pressures under dams and sheets of piles is very usefully presented in the light of recent research, and its application to practice is clearly expressed. Of the next chapter, "Erosion in Streams," it must suffice to observe that the photographs of models and their effects upon flow in model streams are of considerable interest. The third of the chapters, relating to theory and experiment, presents the subject of "Lateral Earth Pressures." A short chapter on "Land Cofferdams" is followed by a 28-page presentment of practical considerations, relating to borings, types of cofferdam, stages in crossing a river, flood protection, erosion protection, and pumping. There follow ten examples of cofferdams, the design and construction being fully described in every case, with an account of how the work was carried out. The volume concludes with eleven views, eight of which depict cofferdam failures; a schedule of wages and prices; a glossary of terms used in the text; a 5-page bibliography, exclusively American; and an adequate index.

Engineering literature in the United States has for some years past been increasingly isolationist in character, but it is surprising to find that the authors did not discover anything worth notice in British publications relating to cofferdams or to recent research work within their field of inquiry. A study of the English literature relating to large works involving cofferdam construction might have saved them from many of their difficulties and failures. It can be accepted, however, that the theory and data of which they have made use suffice for their purpose, and that their book is an adequate presentment of the subject. A large proportion of the 249 illustrations consists of diagrams and drawings, the skilful use of which in elucidating the text is a notable feature of the volume.

Sixty Years Ago

THE CHANNEL TUNNEL

ONCE again the Channel Tunnel scheme attracted our attention in a leading article in our issue of December 30th, 1881, and as on previous occasions our comments were of an adverse nature. At odd moments the daily Press would report that work on the scheme was progressing satisfactorily, but while there was no reason to doubt that some sort of tunnelling operations were in progress near Dover and on the opposite coast of France, we could not discover anything very definite about them beyond the fact that a company was being formed to make the tunnel. We criticised the construction of a Channel tunnel, first, on grounds of military security; and secondly, on the score of finance. From the military point of view, we said, the tunnel would deprive us of the defence which the Channel had provided us with for centuries, and if it were constructed we would require to maintain a standing army on a Continental scale amounting, say, to at least half a million men and costing at least £50 million a year. We estimated that by means of the tunnel France in the event of war could land an army of 50,000 men on our shores within twenty-four hours. That the tunnel could be flooded in time to prevent the landing was, we considered, doubtful. On the financial side we said that the smallest cost for constructing a long railway tunnel was £30 per yard, the figure realised in connection with the Lydgate tunnel, 1332 yards long, on the London and North-Western Railway. It would, however, not be safe to estimate the cost of constructing the Channel Tunnel at less than £200 per yard, so that the whole length of 22 miles would involve a capital expenditure of £7,744,000. At 4 per cent. the interest on that sum would require the provision of £310,000 per year.[1] Taking the working expenses at the same figure, we concluded that the tunnel would require to earn £28,181 per mile per annum, or seven times as much as the figure —£4000—considered an excellent result for ordinary tunnels. Until reasonable proof was forthcoming that the tunnel could earn such an income those who bought shares in the Channel Tunnel Company deserved, we said, to lose their money and they would get what they deserved.

Continental Divide Tunnel, U.S.A.

THE Colorado to Big Thompson project, of which the Continental Divide tunnel forms a part, is intended to provide for the diversion of surplus from the headwaters of the Colorado River on the western slope of the Continental Divide to lands on the eastern slope in North-Eastern Colorado, to supplement the present inadequate irrigation supply. Hydro-electric power will also be developed.

The general plan provides for a storage

EAST PORTAL

reservoir with a capacity of 482,000 acre-feet, to be formed by the construction of a dam 288ft. in height across the Colorado River; the pumping of the water an average height of 130ft. into Shadow Mountain Lake; the diversion of 550 second-feet of water through the Continental Divide tunnel, 13·1 miles long, extending from the easterly end of Grand Lake through the Divide to a point on the watershed of the Big Thompson River near Estes Park; the carriage of the water in the Big Thompson to various points where it will be utilised for power development and stored in reservoirs and finally distributed through existing irrigation systems to the lands in Northern Colorado; and the construction of power plants and transmission lines. Although the diversion of water for irrigation is the principal purpose of the project, as much as 900,000,000 kWh of electric energy per annum, it is estimated, will be obtainable.

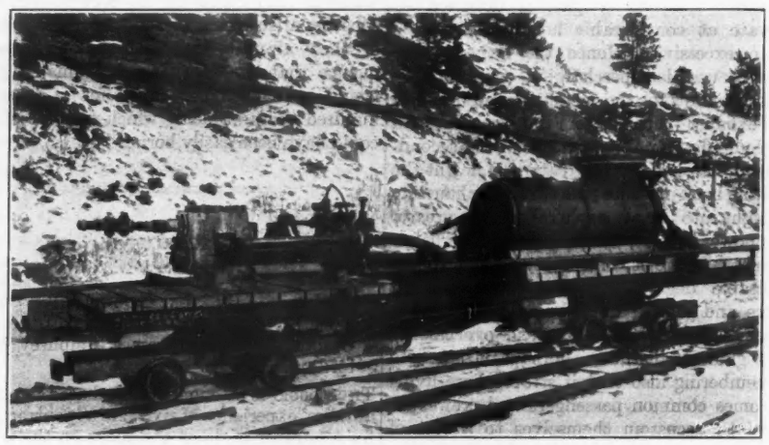
The lands to be irrigated consist of 615,000 acres in North-Eastern Colorado. There are 175,000 people living in the territory benefited by this project, who derive their livelihood either directly or indirectly from farming. The project differs from others in which the irrigation system from the main canals to the individual farm laterals must be constructed, settlers brought in, buildings erected, and a vast amount of "dead" work done before the farms and irrigation systems are going concerns. For in this case the irrigation systems are built, the buildings are erected and the settlers are well established and producing crops on the land. All that is needed is the means of storing and conveying sufficient supplemental water to mature the crops and to ensure the farmers against periodic and sometimes extended droughts.

The construction charge for liquidation of the irrigation project costs is estimated at 2 dollars an acre-foot for a forty-year period. At the present rate of progress the construction will take about five years to complete, depending upon the amount made available from year to year. The present plans outline a programme whereby the various features of the project, except power plants, will be complete and ready to go into operation upon the completion of the Continental Divide tunnel.

The tunnel, 13·1 miles long, is the largest unit of the project and will divert water from the western to the eastern slope of the Continental Divide. The section will be circular, 9·75ft. in diameter inside the lining. When completed, the tunnel will be the longest in the United States to be driven from two headings. It will have a capacity of 550 second-feet. The designed slope of 0·00155 will result in a difference in elevation between the portals of 107ft. The principal items of work involved in the construction will be the excavation of approximately 370,000 cubic yards of materials and the placing of approximately 113,000 cubic yards of concrete.

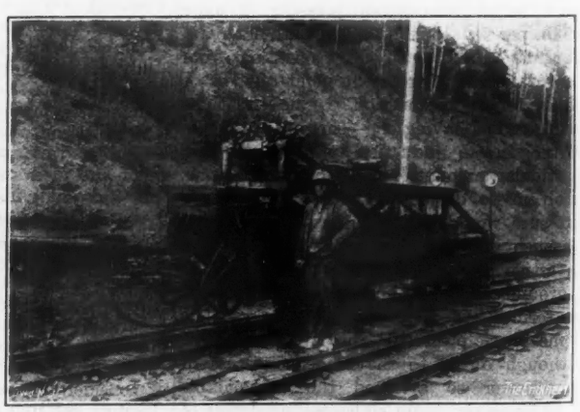
The west tunnel portal at the inlet end will be connected with Grand Lake by a gate control structure constructed so that the water from Grand Lake will discharge into the tunnel inlet channel at a depth varying from 5ft. to 12ft. below the water surface to eliminate ice obstructions.

The work of boring the tunnel will be done in sections, the length of which will depend on the type of rock encountered. As the contract for each unit of the tunnel is let, specifications for later sections are issued. On completion of each contract the contracting officer computes the total yardage excavated in all sections of the bore, except those supported by liner plates, and if the total yardage exceeds the total volume within the excavation pay lines for such sections a penalty of 15 dollars per cubic yard will be assessed. This penalty makes it necessary to use great care in drilling a round of holes



TUNNEL GROUTING MACHINE

EAST PORTAL AND BLOWER HOUSE



DRILLING JUMBO FOR TUNNEL

to prevent overbreak. Considerable blocky ground has been encountered so far, making it necessary to use shorter rounds than would normally be drilled, if there was no penalty for overbreaking. In all types of ground a maximum number of holes is required along the rib line. On several occasions grouting has been necessary to cut off water fissures.

Rocks thus far encountered have been various granites and schists. In several sections a hard igneous rock has also been encountered. From a detailed geological survey by Government engineers, together with reports of conditions actually met in driving the Moffat railway tunnel under the Continental Divide, about 25 miles due south of this one, it was originally estimated that there would be only 400ft. of bad ground and 5200ft. of ground needing support. However, estimates were based on 6900ft. of bad ground and 17,500ft. of ground needing support. Experience thus far indicates that even these revised estimates are likely to prove low.

So far the work at the west portal has advanced 2150ft., the last 200ft. through very unstable ground with considerable water. Trouble has been experienced in holding this rock, even with 6in. steel rib supports set on 12in. centres, and held in place with 6in. steel struts across the bottom. On the east side geologists anticipate that similar ground conditions will be met 12,000ft. to 14,000ft. from the east portal.

In Glacier basin, near the east portal, 2 miles of the tunnel are covered by a thick mantle of glacial drift. The ground surface is from 450ft. to 550ft. above the tunnel level, but in order to be certain that the drift did not extend down to the tunnel level a seismic refraction survey was made with stations every 500ft. Later, to check results, three test holes were put down along the line in this section. Two other drill holes were sunk at a point on the tunnel line approximately 3 miles from the east portal to test for some fractured ground. A study of the seismic and drill hole data indicates a bed-rock profile, with at least 225ft. of rock above tunnel gradient.

Excavation of the first 8000ft. of the tunnel from the east portal was completed early this year after 73·5 per cent. of the time had elapsed for completion of the contract. Prior to the completion of this contract bids were opened for excavation of an additional length of 7000ft. and concrete invert of 14,639ft. From June this year the work was begun and has advanced at an average rate of 50·8ft. per twenty-four-hour day, with 41·8 per cent. of the work completed and 21·1 per cent. of the excavation time having elapsed.

The plans were prepared in the office of the Chief Engineer, Bureau of Reclamation, Colorado.

Accompanying engravings show the east portal of the tunnel soon after operations had been begun and some months later, when a 220ft. extension had been constructed and a blower-house erected. Another engraving illustrates a drilling jumbo. It has two air hammers mounted in front with two more ready to mount on top. Platforms on each side can be lifted into the horizontal position to afford working room for the men. A grouting machine is also illustrated. Grout ingredients are placed in a cylindrical mixing tank at the rear of the machine and after mixing are dumped into an auxiliary tank, whence they are pumped to the area to be grouted.

THE GREAT WESTERN RAILWAY announces that MR. F. WELLER has been appointed assistant to the general manager for special duties.

Locomotive Balancing*

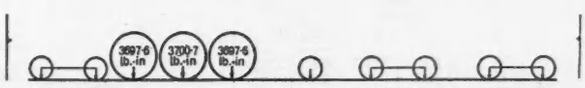
INVESTIGATIONS begun in India after the Indian Bridge Committee had published a study of American track-stress experiments showed considerable divergence in the over-balance and underbalance of locomotive wheels. The worst underbalanced metre-gauge example, of −15 per cent., was found in 4–6–0 express locomotives of the Madras and Southern Mahratta Railway, which had given eminently satisfactory service for many years. Actually, the −15 per cent. was not the fault of the designers or builders. Another discovery was that in every one of a large number of metre-gauge locomotives examined, the counterweight on the main driving wheels was inadequate to balance the rotating masses on that wheel. The result was a heavy hammer blow under the crank pin; usually hammer blow is on the opposite side of the wheel. Similar investigations on broad-gauge locomotives revealed overbalances ranging from 80 to 13 per cent., but, at that time, no underbalances.

In 1930 one of the authors published an argument that if U denoted the unbalanced proportion of the reciprocating parts R, M denoted the mass of the engine without tender and L denoted its length, the effect of the unbalanced proportion of R in causing oscillating variations in draw-bar pull was proportional to UR/M, and the effect tending to produce nosing was roughly proportional to UR/ML² in locomotives of similar type and gauge. In both cases the effect was proportional to UR/M. It was shown that as the weight of locomotives increased, the ratio R/M decreased rapidly and steadily. This being so, U could be increased without the effects being any worse than they had been in the past. Yet the fact was that, owing largely to the state of affairs revealed by the British Bridge Stress Committee, designers were paying more attention to balancing and U was decreasing instead of increasing.

On the M.S.M.R. in 1932 two "YC" class heavy metre-gauge 4–6–2 locomotives were rebalanced, taking into account 20 per cent. of the reciprocating parts. Trials were also made with "W" class broad-gauge locomotives with no reciprocating parts balanced. In June, 1935, the C.M.E. of the railway reported that "W" class engine "No. 776," which had been rebalanced for 20 per cent. reciprocating parts, had run 40,000 miles, and that wear on axle-boxes and side rod bushes was perfectly normal. "W" class engine "No. 773," which had been rebalanced with no reciprocating parts balanced, had been running for four months and was reported to ride perfectly satisfactorily. This type of locomotive came to be known as the "RO" type, and in this paper "RO" indicates an engine with no reciprocating parts balanced. By that time sufficient data were at hand to enable the C.M.E. to conclude that there was no apparent reason why the proportion of reciprocating parts balanced should not be reduced to a maximum of 20 per cent. There were also indications that it might be possible to cut out all reciprocating balance.

In 1938 the Bhita disaster on the East Indian Railway focused attention on the "XB" "Pacific" engine, and the M.S.M.R., which owned many of these engines, made trials with them. Of the twenty-one engines tested, five were "RO" engines. Five "XB" engines were selected which had run as nearly as possible the same mileages as the "XB/RO" engines. In the course of twenty-one runs three cases of severe oscillation did occur, but in no case was an "RO" engine involved. It may be added that those three engines had done between 80,000 and 110,000 miles, whilst no "RO" engine had done more than 69,000 miles since the last heavy repair. In April, 1939, a further series of tests was made on "YC" metre-gauge locomotives, three of which were of the "RO" type. In this series of tests the sideways oscillation in the case of the "RO" locomotive was distinctly less than that recorded for the normally balanced locomotives.

When, in 1935, "XB" locomotive "No. 202," which had been rebalanced for no reciprocating parts, had completed 55,000 miles on ordinary passenger train service, it came into the shops for light repairs. The riding of this locomotive was reported to differ in no noticeable manner from other "XBs" with orthodox balancing, and no defects had developed. The C.M.E. reported that, as regards the condition of the side rod bushes and draw gear, there was no difference in the wear beyond those variations met with in ordinary practice and that, if anything, the condition of the axle-boxes of "No. 202" was slightly better than was normally found. As a result of this report it was decided to rebalance six more "XB" engines and six more "W" engines, eliminating all overbalance.



Axle-loads, engine and tender empty: tons.	20·5	15·3675	15·4375	15·075	14·7625	17·2625	16·9375	Total tons 115·3625
Axle-loads, engine and tender in working order: tons.	22·05	17·00	17·025	17·075	16·95	33·888	33·425	157·413
Axle hammer-blow at 74 m.p.h.: tons.	—	5·293	5·297	5·293	—	—	—	15·883
Total axle-load at 74 m.p.h.: tons.	22·05	22·293	22·322	22·368	16·95	33·888	33·425	173·296

"THE ENGINEER" SWAIN &c

FIG. 1—*Balancing Calculations, 5ft. 6in. Gauge "XB/1" Class Locomotive*

In a common criticism of the policy of balancing locomotives without overbalance is that the wear in the horn cheeks and axle-boxes will be excessive. Deductions from an indicator diagram from an "XB" locomotive taken at a speed of 70 m.p.h. with 15 per cent. cut-off showed that the resultant of the forces at the crank pin could be resolved into a horizontal force which must be resisted by the axle-boxes and horn cheeks; a vertical force which, added to the static wheel load, constituted the dynamic vertical force on the rails; and the torque causing the driving wheels to rotate. These forces and the torque were computed and plotted for both "RO" and ordinary engines, and the horizontal force on the horn cheeks, instead of being excessive, was shown actually to be smaller and more even for an "RO" engine than for an ordinary engine. The vertical force on the rails for an "RO" engine is practically constant, the slight divergence from the straight line being due to steam effect. The torque for an "RO" engine is considerably less variable than for the ordinary type. The calculations made and the actual experience with "RO" engines should, in the authors' opinion, dispose finally of the contention that without overbalance there is bound to be excessive wear. On the metre-gauge section of the M.S.M.R. considerable progress had been made in rebalancing locomotives, and in 1936 a large number of different types were rebalanced for no reciprocating parts.

The Indian Bridge Standards Committee stated in 1937, as a result of M.S.M.R. experience, that it realised that if hammer blow in locomotives could be eliminated, and also if rail joints on bridges were eliminated by welding lengths of rails together, expansion joints being provided over piers where neces-

* Abstracts from two papers presented to a joint meeting of the Institution of Civil Engineers and Institution of Mechanical Engineers, held on December 16th. The first, entitled "Hammer Blow in Locomotives: Can it be Abolished Altogether?" was prepared by Sir Harold Colam and Major J. D. Watson, of the Madras and Southern Mahratta Railway; the second, "Balancing of Locomotive Reciprocating Parts," was prepared by Mr. E. S. Cox, of the L.M.S.R.

sary, two of the main causes of impact on bridges would disappear and there would be a good case for revision of the impact formula to take cognisance of these special conditions. Experiments asked for by the Committee were carried out in 1938, with a special test train consisting of an "XB/RO" locomotive coupled by an empty bogie passenger coach to a normally balanced "XB" locomotive, except for a bridge of 131ft. span, where two bogie coaches were used. As the two engines were coupled, the variation of speed was eliminated and the resulting impacts were more readily comparable. In the broad-gauge tests undertaken, only "XB" class engines were used. The normal "XB/1" locomotive is balanced for 66 per cent. reciprocating parts distributed equally between the leading, driving and trailing coupled wheels.

As wide a range of bridge spans as possible was used, viz., from 12ft. to 131ft., taking into consideration that it was feasible to use only the north-west line of the M.S.M.R., where the "XBs" are in regular service, and sufficient time is available between trains to carry out tests. Deflections and stresses were first measured at the crawl, while the train was backing at about 3 m.p.h., and again as nearly as possible at 60 m.p.h., at which speed several runs were made. In the case of the 131ft. span lower speeds were also run to try to obtain resonance, which was calculated to be at 3·77 r.p.s., corresponding to 49 m.p.h. Table I summarises the results on spans of different

TABLE I.—*Summary of Results of Bridge Tests, M.S.M.R.*

	Deflecto-meter results.		Extenso-meter results.	
	XB/1 /RO.	XB/1.	XB/1 /RO.	XB/1.
	Per cent.	Per cent.	Per cent.	Per cent.
12ft. Span :				
Maximum recorded impact	20·0	20·0	54·5	63·7
Average maximum impact	14·3	20·0	41·6	57·2
Calculated maximum impact	—	100·0	—	100·0
15ft. 9in. Span :				
Maximum recorded impact	20·0	30·0	25·0	56·2
Average maximum impact	10·3	17·4	23·6	39·2
Calculated maximum impact	—	100·0	—	100·0
20ft. 3in. Span :				
Maximum recorded impact	45·5	72·7	—	—
Average maximum impact	34·1	47·8	—	—
Calculated maximum impact	—	96·6	—	—
30ft. Span :				
Maximum recorded impact	25·0	40·0	52·0	44·0
Average maximum impact	12·9	25·9	20·5	29·7
Calculated maximum impact	—	84·7	—	84·7
50ft. Span :				
Maximum recorded impact	23·8	38·1	53·8	69·2
Average maximum impact	19·7	26·6	41·0	53·8
Calculated maximum impact	—	66·7	—	66·7
64ft. Span :				
Maximum recorded impact	8·0	24·0	28·3	46·7
Average maximum impact	6·5	17·0	17·8	37·7
Calculated maximum impact	—	57·8	—	57·8
131ft. Span :				
Maximum impact	4·6	11·6	36·4	45·5
Average maximum impact	1·97	8·9	12·5	25·1
Calculated maximum impact	—	35·9	—	35·9

lengths. In the shorter spans the deflections are so small that impacts can be regarded as only very approximate. A difference in reading of 0·01in. is liable to alter the impact by from 20 to 30 per cent. Similarly, small stresses were measured in some bridges, and a difference of 0·1 ton per square inch might alter the value of the impact by from 20 to 30 per cent. Caution, therefore, should be used in interpreting the results. In the larger spans—64ft. and 131ft.—there is, in both the deflection and the stress records, a very marked resonance effect under the "XB/1" engine which is not noticeable under the "XB/1/RO" engine. Actual resonance was not attained in either bridge, because in the 64ft. span, 80 m.p.h. was a speed too high to attain, whilst in the 131ft. span, unfortunately, no runs were made at 49 m.p.h., the calculated critical speed. The difference is, however, sufficiently striking to show the relief afforded to bridges by rebalancing for no reciprocating parts. These results were considered by the Indian Bridge Standards Committee at Delhi in 1939, and the Committee recommended that, when considering stress imposed by locomotives with no reciprocating parts balanced, on existing bridges, impact should be taken as 80 per cent. of the usual allowance.

BRITISH PRACTICE

The proportion of about two-thirds of the reciprocating weights balanced has been generally adhered to until recently, and on the largest classes of multi-cylinder passenger engines on the L.M.S., L.N.E. and G.W. railways a conservative reduction towards 40 per cent. has been made. As against this the G.W.R. has on certain two-cylinder suburban tank engines increased the proportion to 85 per cent., as a contribution to the avoidance of fore-and-aft oscillations which are unpleasant to passengers. The Southern Railway, on the other hand, has adopted figures of 40 per cent. and 30 per cent., and on its most modern three-cylinder design has eliminated reciprocating balance altogether.

On two-cylinder engines the usual practice for many years has been to divide the weight required to balance the reciprocating parts equally among the coupled wheels, with the object of lessening the hammer blow per wheel and per axle. Three-cylinder engines having cranks at 120 deg. are dealt with in two different ways. The L.M.S.R. balances two-thirds of both inside and outside reciprocating weights, the whole amount being equally divided between the coupled wheels. There is thus in each wheel a component for inside cylinder, outside cylinder, and cross-couple. The resultant balance weight and hammer blow effect is in nearly opposite directions in the left-hand and right-hand wheels; so that while there is an appreciable blow on each wheel and each rail, there is only a negligible amount on each axle and on the engine as a whole. Such an engine, although exerting a smaller hammer blow per rail than a two-cylinder engine, by reason of its lighter reciprocating parts per cylinder, is nevertheless inferior to a four-cylinder engine, and the L.M.S.R. three-cylinder 4–6–0 engines of class "5X" exert as great a hammer blow per wheel and per rail at 5 r.p.s. as the larger and more powerful four-cylinder "Coronation" engine does at 8 r.p.s.

The method adopted by the L.N.E.R. is to distribute the outside balance among all the coupled wheels in the usual way, but to balance the inside reciprocating parts in the main driving wheels alone. This has two results. First, because there is no component for the inside cylinder in the leading and trailing wheels,

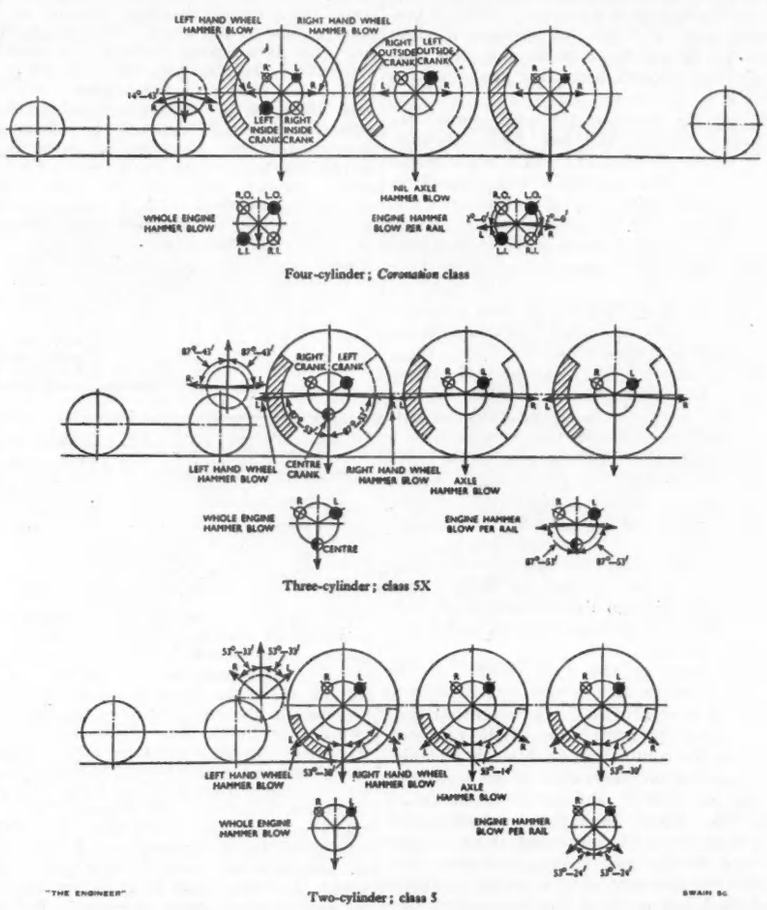


FIG. 2—*Typical Hammer Blow Diagrams for Two, Three and Four-Cylinder Engines—L.M.S. Railway*

the left-hand and right-hand wheel blows, instead of being almost exactly opposite as in the case of L.M.S.R. locomotives, are now approximately 120 deg. apart, so that instead of an inappreciable axle hammer blow, there is a very definite variation in load. Secondly, since the whole of the inside balance is in the driving wheels—and this is, of course, much heavier than the one-third of the outside weights balanced therein—the inside balance weight becomes master of the situation, and the axle hammer blow on the driving wheels occurs in the opposite direction from that on the leading and trailing wheels. There is, in consequence, a considerable reduction in the whole engine blow.

In the case of four-cylinder engines, driving on to a single axle and having adjacent inside and outside cranks at 180 deg., and left and right-hand pairs at 90 deg. to each other, the reciprocating parts on each side balance one another almost completely; but balance weights are introduced to deal with the cross-couple, the required weight usually being equally divided

among the coupled wheels. The hammer blow per axle and per engine is thus nil, but there is a small blow per wheel and per rail. Where the drive is divided, the inside cylinders driving the leading axle, and the outside cylinders the intermediate axle, the same remarks hold good, provided that it is assumed that the side rods adequately keep the two reciprocating systems in phase. The G.W.R., unlike the L.M.S.R., divides the inside balance between leading and trailing wheels only, and the outside balance between intermediate and trailing wheels. This is done with the object of reducing stresses in side rods and frames, but it results in a definite blow per axle, as against no blow by the L.M.S.R. method.

The outstanding change since 1928 has been in speed. The Bridge Stress Committee's recommendations were based on a rotational speed of 5 r.p.s. Before the war maximum operating speeds had risen to 90 m.p.h., while on special tests speeds up to 125 m.p.h. had been attained. Moreover, high speeds have not, as formerly, been confined to large-wheel engines, thus keeping the speed of rotation down. If it is going to be required in future that engines shall develop at 8 r.p.s. no greater hammer blows than they do now at 5 r.p.s., a cylinder engine (as shown in an appendix to the paper), from the expression $A = W d r m / \sqrt{2}\, g\, I$, where A denotes the semi-amplitude, in inches, of oscillation at the bogie centre, m the horizontal distance of the bogie centre from the centre of gravity of engine, in inches, and I the moment of inertia of the engine about a vertical axis through its centre of gravity. The amplitude is independent of speed of rotation. In simple terms this means that while the disturbing force increases as the square of the speed, so also does the resistance of the mass of the engine to displacement, the effect of speed thus being nullified. In so far as lateral nosing movement alone is concerned, therefore, there appears to be no necessity to introduce reciprocating balance on any modern engines; but the situation is otherwise when the longitudinal disturbing forces are studied.

The second of the longitudinal forces applied through the axle-boxes and frames is due to the effect of the unbalanced reciprocating parts, which attains a positive and a negative value for each cylinder once during each revolution. The resultant effect depends upon the number of cylinders and the crank angles between them. On three and four-cylinder engines of conventional type the primary horizontal forces due to the reciprocating parts are in balance among themselves, given equal connecting-rod weights, and no variation in tractive effort at the drawbar arises from this cause. Theoretically, no additional balancing of these parts is therefore necessary on such engines. On two-cylinder engines the forces in question do not balance, and the resultant takes the form of a fluctuating force tending to accelerate and decelerate the locomotive along its longitudinal axis, with a frequency of once per revolution. The maximum value of this force for such an engine is $\pm \sqrt{2}\, W \omega^2 r / g$.

The manner in which the force due to steam pressure and that due to unbalanced parts vary with speed is shown by investigatons on a large two-cylinder engine having 50 per cent. of its reciprocating parts balanced. At low speeds the steam pressure effect predominates, but as speed rises the effect of the unbalanced parts increases, until at 90 m.p.h. there is an alternating force which ought to cause the draw-bar pull to fluctuate between +23 tons and −15 tons each revolution. Such large fluctuations are not felt on the footplate or in the train, nor are they recorded on the dynamometer car chart. The explanation lies in the fact that the frequency of the disturbing force is many times greater than the natural frequency of the elastic system as a whole, comprising the mass of the locomotive and of the train and the elastic characteristics of the draw-bar springs. It may readily be shown that there are many categories of two-cylinder locomotive in which some degree of reciprocating balance is necessary. For example, the L.M.S.R. 4–6–0 mixed traffic engine weighing 72 tons requires 933–530 lb., *i.e.*, 403 lb. balanced if undue oscillations above ±0·2 ton at the draw-bar are to be avoided. This represents 43 per cent. of the reciprocating weights balanced, and actually the balance has been standardised at 50 per cent. on this class.

The modern locomotive is capable of speeds up to 8 r.p.s. and the resulting hammer blows with the usual percentages of reciprocating balance can attain much higher values than were visualised in the Bridge Stress Committee's report in 1928. The phenomenon of wheel bouncing at high rotational speeds was first observed in America in 1937, and tests have shown that it can occur in British practice in certain circumstances. As regards the effect on the locomotive, longitudinal and nosing oscillations depend on the weight and length of engine, weight of reciprocating parts unbalanced, and characteristics of the draw-bar springs. They are independent of speed. Theory suggests that three and four-cylinder engines which are already in a state of balance with regard to longitudinal forces do not require any portion of their reciprocating parts to be individually balanced to deal with the nosing couple, because of the small magnitude of the displacement. In two-cylinder engines, theory—supported by a certain amount of practical evidence—indicates that some degree of reciprocating balance is still required if undue longitudinal oscillations are to be avoided. The percentage required will vary with the engine characteristics. Not less than 40 per cent. balance appears to be required on the heavier type of British two-cylinder engine weighing from 65 to 75 tons. For the highest speeds multi-cylinder engines are the most desirable. If it is thought necessary to balance a percentage of the reciprocating parts, the four-cylinder is preferable to the three-cylinder type, from the point of view of hammer blow. If this balance is eliminated there appears to be little to choose between the two types. The final criterion as to what percentage of balancing is necessary is the magnitude of the oscillations which can be admitted on the engine, having regard to riding comfort for engine crew and passengers, wear and tear, maintenance costs and safety.

TABLE II.—*Hammer Blow Particulars for Various British Engines*

Type of Engines.	No. of cylinders.	Reciprocating weight per cylinder.		Percentage balanced.		Speed.		Hammer blow.						Total hammer blow per rail, tons.	Whole engine hammer blow, tons.	Weight of engine in working order, lb.
								Per wheel.			Per axle.					
		Inside, lb.	Outside, lb.	Inside.	Outside.	R.p.s.	M.p.h.	Leading, tons.	Intermediate, tons.	Trailing, tons.	Leading, tons.	Intermediate, tons.	Trailing, tons.			
L.M.S.R.:																
4–6–2 "Coronation" ...	4	698	663	47·3	49·8	5	72	1·31	1·31	1·31	Nil	Nil	Nil	3·47	0·24	242,144
						8	115	3·35	3·35	3·35	Nil	Nil	Nil	8·88	0·61	
4–6–0 class 5	2	—	933	—	50*	5	64	2·95	2·95	2·95	3·50	3·50	3·50	7·59	9·03	161,504
						8	103	7·55	7·55	7·55	8·95	8·95	8·95	19·40	23·10	
L.N.E.R.:																
4–6–2 A4 class	3	593	517	40	40	5	71	1·33	2·16	1·33	1·16	1·56	1·16	4·74	0·70	230,608
						8	114	3·41	5·53	3·41	2·97	4·00	2·97	12·13	1·79	
2–6–2T V1 class...	3	549	508	60	60	5	61	2·03	2·95	1·99	1·77	1·63	1·79	6·45	2·00	194,880
						8	97	5·20	7·55	5·10	4·54	4·17	4·58	16·50	5·12	
G.W.R.:																
4–6–0 "King" class... ...	4	594	527	34·2	41·8	5	70	1·50	1·79	1·00	2·80	2·03	0·77	0·71	1·54	199,360
						8	111	3·84	4·58	2·56	7·17	5·20	1·98	1·83	3·94	
2–6–2T No. 5101	2	—	731	—	66·6†	5	81	3·35	3·35	3·35	3·93	3·93	3·93	10·05	11·79	175,728
						8	97	8·56	8·56	8·56	10·10	10·10	10·10	25·68	31·50	
S.R.:																
4–6–2 "Merchant Navy"	3	764	798	Nil	Nil	5	66	No hammer blow at all speeds						—	—	207,200
						8	106									
4–6–0 "Lord Nelson" ...	4 (cranks at 135°)	533	567	40	40	5	70	L 1·04	2·10	1·04	0·89	1·76	0·89	4·17	4·10	187,040
								R 0·43	0·86	0·43				1·71		
						8	113	L 2·66	5·39	2·66	2·28	4·50	2·28	10·70	10·5	
								R 1·10	2·20	1·10				4·40		
4–4–0 "School" class ...	3	606	563	30	30	5	70	1·44	—	1·44	0·10	—	0·10	2·87	0·27	150,304
						8	113	3·68	—	3·68	0·27	—	0·27	7·35	0·69	

* Earlier engines of this class have 66·6 and 55 per cent. balanced. † Some of these engines have 85 per cent. balanced.

reduction in the amount of reciprocating balance which can be admitted will be called for.

That the elimination of hammer blow has not been done already is due to the fact that the engine itself must be correspondingly subject to horizontal disturbing forces which—especially in the case of two-cylinder engines—may reach a large magnitude. The effect of these horizontal forces on the locomotive is, unlike the hammer-blow effect, very ill-defined. Neither recorded theory nor experiment has so far analysed clearly the resulting oscillations, showing on the one hand how they vary in relation to engine weight, length, and weight of unbalanced reciprocating parts, and on the other hand what proportion they form of the total locomotive oscillations from all causes.

The effect of the nosing couple is greatest in a two-cylinder engine, in which type its maximum value is given by the expression $W \omega^2 r d / \sqrt{2}\, g$, where W denotes the unbalanced reciprocating weight per cylinder, in pounds or tons, ω the angular velocity, in radians per sec., r the crank radius in feet, and d the distance between cylinder centres in feet. The value of the couple thus increases as the square of the speed.

The action of this couple is resisted by the inertia of the engine, and an expression for the value (in inches) of the amplitude of the resulting oscillation can be worked out for a two-

Tractor Ploughing Demonstrations

IN the last two weeks some interesting tractor ploughing trials have been carried out by the Hampshire War Agricultural Executive Committee, with a view to demonstrating the correct setting of ploughs for varying conditions of land. They were arranged by Mr. L. G. Troup, the Committee's Executive Officer. At the first of these trials, which was held at the farm of the Exors. of G. E. Grey, situated on the main Winchester-Basingstoke road, British Fordson tractors were employed, and the ploughs were of the Cockshutt type, supplied by A. Lister and Co., Ltd., of Dursley, Gloucestershire, and 13, Kingsway, London. The demonstrator was Mr. E. Rea, the agricultural adviser to the firm. These trials were so successful and were so well attended that they were repeated on four other days. The Fordson tractors were provided with spade lugs, rubber tyres and rubber

FOUR-FURROW COCKSHUTT PLOUGHING

tyres ballasted with water, and two, three and four-furrow Cockshutt ploughs were used, the two and three-furrow ploughs being operated with a press.

After the field had been opened up all the essentials of good ploughing were demonstrated, and several lands were then correctly ploughed. A three-furrow plough was then brought into operation which had been purposely maladjusted, and this did typical work which can be seen in many parts of the country. The faulty adjustments were then corrected one by one, and in less than twenty minutes the plough, which hitherto had been producing very uneven and unsatisfactory work, was producing very good work of a high competition standard.

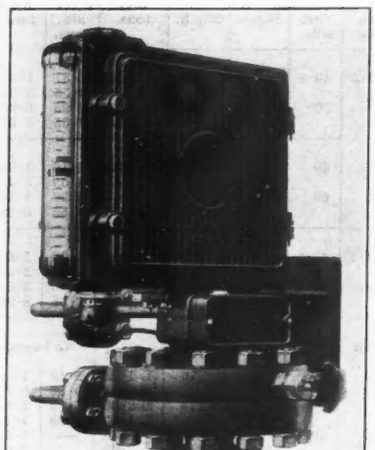
After the demonstration the following conclusions were arrived at:—Ploughing still remains a skilled operation, and the first essential is setting the plough correctly, both to do better work and to reduce unnecessary friction. The fact that a medium-powered tractor with standard equipment was able to pull a four-furrow plough working 10in. wide by 5½in. deep with a soil resistance of 8 lb. per square inch does not mean that all such tractors should attempt four furrows, but it does indicate serious underloading and waste of output to operate only two furrows. Three furrows each 9in. by 6in., plus a three-ring furrow press, provided a lighter load than a four-furrow without a press.

It therefore appears that two furrows and a press may be an adequate load under more severe conditions; three furrows and a press can be used in favourable conditions; and where no press is required three furrows should be used except in very unfavourable conditions. The Hampshire War Agricultural Executive Committee consider the experience gained by these demonstrations of such importance that it is proposed to inaugurate ploughing competitions in the various districts of Hampshire.

Remote Water Level Indicator for Boilers

OWING to the height of the water level gauges on the large boilers now installed in power stations it is difficult to read, clearly and accurately, the position of the water level from the firing floor, and it is therefore essential to overcome this difficulty in order to ensure the efficient operation of the boilers. The remote water level indicator, illustrated herewith, is being made by Hopkinsons, Ltd., of Huddersfield, and is the outcome of several years of experiment and practical experience under working conditions. It can be placed in any convenient position on the firing floor or arranged on the boiler control panel. The equipment, it is claimed, is easily installed, as it is only necessary to run two ¼in. bore pipes between the drum and the indicator.

It was realised that only a direct-acting type of instrument could fully meet all requirements. The indicator is therefore designed to be

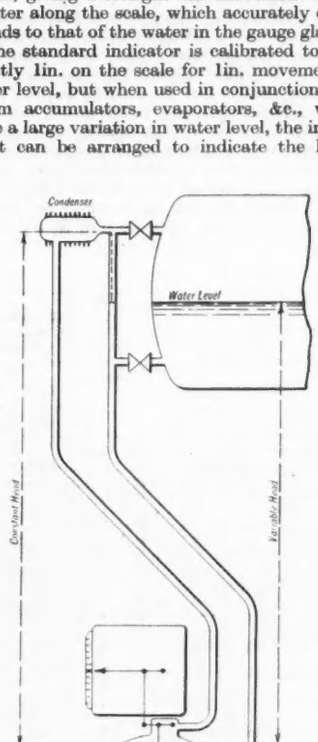


REMOTE WATER LEVEL INDICATOR

operated directly by the actual level of the water in the boiler, the pointer swinging exactly as the water in a gauge glass. Internal illumination, a clearly marked scale and a prominent pointer enable the position of the water level to be seen at a glance from a considerable distance. Another important feature is the curved front of the indicator, giving the maximum range of view possible—over 180 deg. of vision—so that it is unnecessary for the attendant to stand immediately in front of the instrument. The indicator can be supplied in a form suitable for flush-panel mounting, and electric contacts can be fitted to control a hooter, thereby giving audible warning of excessive high or low water, while, in addition, signal lights may also be provided for further indication.

The operating element consists of a large, sensitive diaphragm, one side of which is connected to the steam space of the boiler and the other to the water space. A condenser at the boiler drum maintains a fixed head of water on the steam space side, while the water space side is subjected to a varying head dependent upon the water level in the boiler. This varying head is balanced by a spring in the instrument and causes the diaphragm to move in accordance with the water level. The full boiler pressure, being on both sides of the diaphragm, is therefore balanced and has no effect on the movement of the diaphragm, which is actuated only by the difference in heads. Ample power is obtained by use of a large diaphragm; a variation of 1in. in the head on the diaphragm produces an operating force of nearly 1 lb., and the indicator responds to very small variations in water level. A small stainless steel spindle, passing through a self-sealing frictionless gland, transmits the motion of the diaphragm to the outside of the diaphragm chamber, where it actuates a leverage mechanism, giving a straight line movement of the pointer along the scale, which accurately corresponds to that of the water in the gauge glass.

The standard indicator is calibrated to read exactly 1in. on the scale for 1in. movement of water level, but when used in conjunction with steam accumulators, evaporators, &c., which have a large variation in water level, the instrument can be arranged to indicate the larger



ARRANGEMENT OF WATER LEVEL INDICATOR

movement to a smaller scale. The lamp for illumination is of the opal tubular type with the graduations marked directly on the lamp, which thus forms the scale. A resistance is embodied in the instrument to enable the lamp to be run on a reduced voltage, thereby cutting out glare and promoting a longer life for the filament.

ALUMINIUM TECHNOLOGY.—The demand for accurate, up-to-date information on aluminium technology has increased very considerably as a result of the wartime expansion of industries concerned with the working and treatment of aluminium alloys. To meet this demand, particularly in view of the fact that improvements in technique are continually being made, the research and development department of the Northern Aluminium Company, Ltd., has compiled a number of publications dealing with various branches of the subject. These publications are subjected to periodic revision and their number will, we learn, be augmented in the near future in response to requests from many industrial sources. Those available at the present time are given in the following list. Copies are obtainable by applying to the Technical Publications Department of the company at its Banbury (Oxon.) office. (1) "Gravity Die Castings in Aluminium Alloys," (2) "Cold Forming of High-strength Aluminium Alloy Sheet," (3) "Machining of Aluminium Alloys," (4) "The Heat Treatment of Aluminium and its Alloys," (5) "Protection of Aluminium Alloys During Storage," (6) "Specifications for Aluminium and Aluminium Alloy Products."

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Japan's Shortage of Raw Materials

Even before Japan so abruptly plunged into the war her industrial production had been deteriorating for some time, chiefly because of a scarcity of raw materials and skilled labour. Since the embargo on trade with Japan by the United States, Great Britain and the Dutch East Indies, towards the end of July, Japan had been isolated from some of her most important markets. Ship movements between Japan and the United States, for example, had been non-existent. The United States, Great Britain and the Dutch East Indies accounted, says the *Foreign Commerce Weekly*, which is published by the United States Department of Commerce, for 75 per cent. of Japan's import and export trade with foreign currency countries. Those countries had also been supplying the bulk of Japan's requirements of scrap and other iron and steel, lead, zinc, aluminium, copper, various ores, tin, machine tools and automotive products. Japan is now primarily dependent upon resources within the yen bloc and the prospects of her obtaining her requirements of such essential items as special steels, high-speed machine tools, ball bearings, aluminium, copper and lead are small. There are no facilities in Japan for processing raw materials if these were available. In October a campaign to collect all metal articles was initiated. Old railway cars, posts, wire, nameplates, kitchen utensils, roofing plates, gutters and pipes, manhole lids and railings were amongst the articles collected to augment metal stocks. Even the iron fences around Government and business offices have disappeared. Salvage companies were employed to recover sunken ships to secure more scrap. Iron and copper were the principal items sought, but metals of all kinds were included in the collection. More pig iron is being used by the Japanese iron and steel industry because of the shortage of scrap, and the maximum ratio is reported as being seven parts pig iron to three parts scrap. There is also a shortage of coal, owing to the necessity of using larger quantities of coal to treat low-grade iron ore. In addition to shortages of the materials mentioned, there is a scarcity of many other raw materials, including petrol.

The Pig Iron Market

The pig iron position in Great Britain gives no cause for concern, although naturally there are some variations in the available supplies of the different descriptions. The great thing is that all consumers engaged upon war work are receiving the pig iron they require, and although in some cases they have to use unaccustomed sorts or mixtures, the use of substitutes is causing no disturbance to the consuming industries. The demand for high-phosphoric iron is less than the production and substantial stocks are said to be available at some of the blast-furnaces. Business has become rather quieter, as most of the consumers of pig iron who are engaged upon work of national importance have obtained their licences and have placed orders covering the first delivery period of next year. This applies to practically all descriptions of pig iron and particularly to low-phosphoric iron, which is in brisk request. The hematite position is being closely watched over by the Control and strict restrictions have been placed upon the use of this iron to prevent it being employed in cases where other descriptions of pig iron would serve. The saving in the use of hematite has thus been considerable, and this is of great benefit to the country at a time when the demand for hematite is extremely heavy, and the country has to depend upon its own production resources plus stocks that the Control has had the forethought to accumulate. There has been an increase in the production of refined pig iron, which is in active demand, as it is used in many cases as a substitute for hematite. Some expansion has taken place in the output of ferro-manganese and the producers are hard pressed to fill consumers' requirements. The basic pig iron position is satisfactory and the steel making industry is receiving full supplies. Imports are likely to be restricted in the future, but production in Great Britain is so satisfactory that this causes no concern for the future.

Scotland and the North

The Scottish iron and steel industry is working all-out to meet the demand for war purposes and the finishing departments have experienced increased pressure from consumers to obtain supplies. Very little of the finished steel produced is going into consumption for ordinary civilian purposes. The demand for alloy and special steels continues to increase as a result of the intensification of the munitions drive, and although the production has been increased the makers are operating full time to meet consumers' requirements. Business in plates also shows no signs of declining, although it has been maintained at a high level for some months. The requirements of the tank makers are exceptionally heavy and there is a persistent call for plates from the shipyards. The boilermakers and wagon builders are also big users of this class of material. The marine engineering establishments are fully employed and their steel requirements are on a heavy scale, but they are receiving the full needs which are almost entirely of a priority character. The engineering industry are important users of steel bars and whilst the demand seems to be principally for the larger sizes, the re-rolling industry is fully occupied in producing small steel bars which are required in increasing quantities. In the case of some other products of the re-rolling mills the demand varies and new business in some categories is not sufficient to replace completed contracts. The sheet industry is well placed for business until well into 1942, but some of the works could accept fresh orders were they forthcoming. Most of the work in hand at the sheet mills is for the Government and the demand seems largely for the medium-weight sheets. Great activity prevails in the Lancashire steel industry and there is a particularly strong demand for special steels of all kinds. The plate makers also are operating under extreme pressure and are likely to be busy for a long time. The call for plates of the thicker descriptions is particularly noticeable. Active conditions also rule at the works producing colliery steel, but production is well maintained and there is comparatively little delay in completing deliveries. Bright drawn steel bars are a strong section of the market. The steel works on the North-West Coast are fully employed and are maintaining heavy outputs. So far as can be seen the works have enough business to keep them fully employed over the first quarter of next year.

The Midlands and South Wales

Great activity prevails in all the Midland iron and steel works. Establishments supplying consumers engaged on Government work are fully employed and likely to remain so for an indefinite period. Alloy and special steels are in particular request from the aircraft and armaments industries, and these requirements provide an outlet for most of the steel produced. Little steel is allowed to be used for civilian purposes and some businesses whose production has been devoted to this class of work are now experiencing rather a quiet time. The engineering firms in the Midlands are almost entirely employed upon war work and are absorbing large tonnages of steel bars. At the moment the demand would appear to be principally for the larger diameters, but there is also a good request for smaller sizes. The re-rolling industry is kept well employed in the production of this class of finished steel and also upon strip, for which there is a vigorous call. Perhaps the demand is strongest in the plate department. Some easing of the heavy pressure on the plate mills noticeable a few weeks ago is discernible, but the works producing the thicker plates are kept employed to capacity. The tank makers continue to call for increasing quantities, whilst the shipyards are also big users. The steel makers have also a considerable amount of work in hand for colliery maintenance and there has been a strong demand recently for pit props and arches, which reflects the heavy operations at the mines since the war broke out. The iron and steel situation in South Wales has not greatly altered. Even the steel makers engaged on work of non-essential character find the pressure of demand heavy. Firms engaged on the production of structural steel report an improvement in the demand, although most of them could take on fresh business without any inconvenience. The steel works producing sheet and tinplate bars, however, are not so actively engaged as a little time ago, as the demand from the tinplate works has fallen off; this is due to the restriction upon the export of tinplates. The tinplate industry, however, is operating at a moderate rate and the whole production of tinplates is absorbed by the home market.

The North-East Coast and Yorkshire

Practically the whole of the output of the steel works on the North-East Coast is going into consumption in purposes connected with the war and the melting plants in the district are kept fully employed. The raw materials position is so satisfactory that production is maintained at a very high level. There is some variation in conditions at the finishing plants, and although some producers believe they can see an improvement in the demand for joists and sections, consumers' requirements of both heavy and light sections do not engage the capacity of the producing works. The call for plates, however, is maintained and there are indications that it is increasing. Large quantities are passing to the tank makers, who have been busy for several months, whilst shipbuilders are providing a good outlet and substantial tonnages are going to the boilermakers and wagon builders. Business in colliery steel has expanded of late and the collieries have come into the market for large tonnages. The manufacturers of steel arches, props, &c., however, are fully meeting the supply. The heavy engineering works have lately received considerable orders for plant and equipment and their steel requirements appear to be on an increasing scale. The demand for bars of all sizes has been active for some time and is sufficient to keep producing works, including the re-rollers, busily engaged. Business in ferro-concrete rods is particularly strong and large tonnages are passing into consumption. Great activity rules in the Yorkshire steel industry and the Sheffield steel works are operating at capacity. The demand for alloy and special steels as a result of the intensified munitions drive remains a feature of the market. These steels are, of course, of considerable importance in view of the big requirements of mechanised equipment. The production of acid carbon steel is very heavy and most of the output is absorbed by priority orders. There is also an increasing request for high-speed and tool steels.

Copper, Tin, Lead and Spelter

The outbreak of hostilities in the East does not appear to have affected the copper position in Great Britain. The Non-ferrous Metal Control has been carefully watching the situation for a long time and licences to purchase have not been issued except for essential war work. This position may become somewhat more stringent, but it is not anticipated in the market that supplies will be greatly affected by the activities of the Japanese Navy. The United States may suffer some interruption of supplies of copper from South America, as it has been already reported that Japanese submarines are active off the Pacific coast of that country. The position, however, may be altered by the entry of the United States into the war, which, great as the ultimate benefit will be to the Allies, will probably occasion more extensive use by America of copper. The cutting down of supplies for civilian purposes in the United States is likely to become more drastic, and, of course, one of the problems which will face the British and American Governments is the best method of maintaining supplies for Russia, particularly now that our Ally is hitting the Germans so hard. Of course, there is no news as to the quantities which have been sent to Russia and it must be remembered that the Russian northern ports are frozen up, whilst supplies through Vladivostock may be interfered with by Japanese naval operations. It is probable, therefore, that the metal which is being sent to Russia is going *viâ* Persia and the Caspain Sea. . . . The closing of the Metal Exchange which followed the entry of Japan into the war has been followed by negotiations between the Metal Exchange and the authorities with a view to continuing the market in some form. No agreement has yet been reached and negotiations are continuing. Fortunately, good stocks of tin exist in Great Britain and in the United States, and in this war tin is not so important a metal as in the past. The course of the war in Malaya will undoubtedly affect supplies and the fall of Penang will place smelters at the disposal of the Japanese. Their control of Siam also will give them supplies of tin concentrates, but probably the Japanese smelters have already been working at full pressure on Chinese material. The smelters in this country will probably be able to maintain operations at a high rate upon ore from Bolivia and Nigeria, which are not in the war zone. So far as can be seen, however, there is not a great likelihood of Germany benefiting by supplies of tin which the Japanese have obtained. . . . There is a heavy consumption of lead in Great Britain and little is released by the Control except to consumers engaged upon war work. Makers of armaments, cables and batteries are large consumers, but so far supplies have been adequate to meet all calls, and it is not anticipated that there will be serious interruption to supplies. . . . The spelter position is somewhat similar. The war industries are taking up very large quantities. The brass manufacturers, in particular, are big consumers, and it is satisfactory that there does not appear to have been any interruption of supplies as a result of the outbreak of hostilities in the Pacific.

Notes and Memoranda

Rail and Road

UTILISING WATER SOFTENING SLUDGE.—The disposal of the sludge from its water softening plants has presented considerable difficulty to the L.N.E.R. Now, however, it has been found possible to utilise the lime deposit and already some wagon loads are being sent to market gardeners for use as an artificial manure. Land so treated has produced good results.

STEPHENSON LOCOMOTIVE SOCIETY.—The thirty-second annual general meeting of the Stephenson Locomotive Society was held on December 13th at the "George," Fenchurch Street, London, E.C.3. Mr. J. H. Seaford presided over a good attendance. It was reported that the financial position was strong and that over fifty new members had been elected during the year. The practicability of securing temporary club room premises in London is to be considered by the Council. The acting General Secretary is Mr. J. H. Seaford, Woodlands Cottage, Fulmer Road, Gerrards Cross, Bucks.

Air and Water

A NEW DAM FOR INDIA.—The Government of Bengal proposes, with the approval of the Bihar Government, to construct a reservoir of a capacity of over 6000 million cubic feet in the upper catchment of the Damodar (in Hazaribagh District) in connection with the Howrah-Hooghly flushing and irrigation scheme. The object of the scheme is to flush an area of about 800 square miles in Burdwan. The scheme may cost Rs. 35 lakhs.

PAPER FROM A WATER PLANT.—Consequent on an investigation of a means of eradicating the water hyacinth, Mr. M. A. Azam, of the Industrial Research Laboratory, Department of Industries, Government of Bengal, has devised means for the utilisation of water hyacinth in the manufacture of paper and pressed boards. A process of preparing pulp from the plant has been worked out, which, it is stated, may be followed on a cottage scale in the villages of Bengal.

THE SEARCH FOR PURE WATER.—The U.S. Bureau of Mines has issued a preliminary report on researches on activated carbon from coal refuse. A good grade of activated carbon suitable for water purification can be made from a carbonised material high in ash, although the activity of the product decreases steadily as the ash content of the coal increases. So far, activation by steam and zinc chloride has been studied, but other chemical activators are to be investigated.

PORT TO CITY PIPE LINE.—Completed in record time, the Portland, Maine-Montreal, Quebec, oil pipe line has been put into service. Known as the Esso pipe line, this 236-mile long welded steel tube will be able to carry 50,000 barrels of oil per day to the Montreal refineries of Imperial Oil, Ltd. Tankers now bringing oil from South American ports in Venezuela and Colombia will unload their cargoes destined for Eastern Canada at a new pier in Portland. Eight pumping stations, spaced about 30 miles apart, will force oil through at a maximum speed of 3½ m.p.h. The oil will be about three days *en route*.

Miscellanea

NO NICKEL FOR COINAGE.—The Danish Parliament has before it a Bill for the introduction of zinc coinage because all stocks of nickel-containing materials and alloys have been requisitioned by the Directorate of Supply.

TUNGSTEN FROM THE ARGENTINE.—Argentina is to sell to the United States the whole of her annual output of tungsten—up to 3000 tons a year—for the next three years. Argentina's output of tungsten in 1940 was 1700 tons.

CHINA INSTALLING WOOL COMBING MACHINERY.—Our contemporary, the *Far Eastern Engineer*, reports that the plant being supplied to the order of the Shanghai Worsted Mills, Ltd., for erection "somewhere in Szechwan," includes wool combing machinery. This factory with that of the Chinko Mill, formerly of Peiping, later of Hankow, and at present of Chungking, will thus be the only mills equipped to manufacture from Chinese wool. The machines for both have been made in Yorkshire.

GIANT MAGNETS.—A magnet, which on test lifted a load of 25 tons, has been installed by the American Rolling Mill Company. It was rated to lift about 18 tons, with a safety factor of 50 per cent. The makers propose now to build larger magnets of similar design, each with a rated capacity of nearly 75 tons.

CANADIAN TIN.—Tin, until a few months ago one of the few important metals Canada did not produce, is now being smelted in British Columbia at the rate of 500 tons annually by the Consolidated Mining and Smelting Company, of Trail. This production is approximately 15 per cent. of Canada's total annual need of the metal.

BAUXITE FOR THE AXIS.—There are three mines in Hungary producing bauxite and figures recently published show that in 1940 103,112 metric tons were mined, against 26,678 tons in 1938. The silica content of the first-quality ores varies between 1·2 and 12 per cent. Some of the ores also contain beryllium and vanadium in more than normal amounts.

THE U.S.A. TO GET MORE MAGNESIUM.—The Diamond Alkali Corporation, of New York, is to construct and operate at Painesville, Ohio, a plant for the production of magnesium from native dolomite. Another concern, Basic Magnesium, Inc., of Cleveland, Ohio, has placed a 3,000,000 dollar contract for the erection of a magnesite treating plant near Luning, Nev. This plant will convert locally mined magnesite into magnesium oxide, which will be converted into magnesium metal at another works being built near Las Vegas, Nev.

FEWER SECTIONS.—The U.S.A. Defence Authorities have requested the steel industry to reduce sharply the number of sizes of structural steel beams, channels, and angles, and a simplified list of sizes is scheduled to come into effect on February 1st, 1942. The purpose of the move is to avoid tying up mills with small orders for odd-sized rollings. The simplified schedule has been drawn up after consultation with the Army, the Navy, and the Maritime Commission, as well as with architects, engineers, and designers. Shapes regularly used in ship, car, and building construction are retained.

TO CONSERVE ALUMINIUM.—The American Defence Authority has received a report from experts of the National Bureau of Standards and the Institute of Paint and Varnish Research giving recommendations for materials which can be substituted for aluminium paint. It is indicated that there is probably no one paint which has all the desirable properties of aluminium paint for special uses, keeping in mind such properties as durability, visibility, low emissivity, impermeability, and opacity. There are, however, a number of types of paints which are available that should prove satisfactory. The various recommendations cover painting of structural steel, metal roofs, smoke stacks, interior structural steel, radiators, and interiors, such as plaster walls and woodwork.

ASLIB ANNUAL GENERAL MEETING.—The sixteenth annual general meeting of the Association of Special Libraries and Information Bureaux was held at the Royal Institute of British Architects, London, on Saturday, December 13th, 1941. The chair was taken by the President, Sir Harry Lindsay, K.C.I.E., C.B.E., Director of the Imperial Institute, whose introductory remarks touched on the widening scope of the Association's activities, a subject that was further developed by Mr. E. J. Carter, the Honorary Secretary, in his review of the year's work. The Association had been lucky enough to come through the winter's air raids with only minor damage to the office; membership remained steady and publications continued as usual. New opportunities for service arising from war conditions had been seized, amongst which was the investigation into the location and supply of scientific and technical periodicals now reaching the country from enemy and enemy-occupied territories, a survey carried out under the auspices of the Royal Society and the Rockefeller Foundation. Further details of the information thus compiled can be obtained on application to the Aslib Office at 31, Museum Street, London, W.C.1. Other projects for bibliographical co-ordination are being considered.

AUSTRALIA FINDS MORE OIL.—What is claimed to be "payable oil" has been discovered at Lakes Entrance, a holiday resort and fishing centre on the south-east coast of Victoria. It is not far distant from one of the largest brown coal deposits in the world at Morwell, near Gippsland. It has a low petrol content, but is suitable for oil engines, lubrication and bitumen recovery.

INDIA AND POWER ALCOHOL.—The severe rationing of petrol in India has led to the question whether power alcohol cannot be obtained from molasses and so utilised for motor vehicles. Molasses is a by-product of the sugar mills, at present mostly going to waste. The difficulties of the present situation have evoked several exhortations to the Government of India to grant facilities for the production and use of power alcohol from molasses.

FORD FOUNDRY NEARING COMPLETION.—Consequent on expanding war production, an addition to the foundry building at the Windsor plant of the Ford Motor Company of Canada, Ltd., is nearing completion. As soon as the floor is laid a battery of five new electric furnaces and other equipment will be installed. Three of the new furnaces will be used for melting alloy steels to provide a total of six 4½-ton melter furnaces. The other two new furnaces will be holding furnaces designed also for melting. The steel casting capacity of the foundry will be increased by more than 100 per cent. when the new equipment is brought into production.

Personal and Business

MESSRS. W. J. SELBY and D. M. BALFOUR have been appointed directors of Balfour, Beatty and Co., Ltd.

MR. F. PURSER FLETCHER has retired from the position of Deputy Director of Electrical Engineering to the Admiralty.

MR. G. R. THURSFIELD, M.I. Mech. E., has been appointed managing director of Sturtevant Engineering Company, Ltd., in succession to the late Mr. G. A. Mower.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Scientific Workers

Saturday and Sunday, Jan. 10th and 11th.—Caxton Hall, Westminster, S.W.1. Conference, "Science and the War Effort." 10 a.m. each day.

Bradford Engineering Society

Monday, Jan. 12th.—Technical College, Bradford. "Vacuum Return Heating for Mills," F. C. Lant. 7.15 p.m.

Institution of Automobile Engineers

Sunday, Jan. 11th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "Some Applications of Photography in Engineering," B. Eyden. 2.30 p.m.

Institution of Civil Engineers

Saturday, Jan. 3rd.—N.W. ASSOC.: Engineers' Club, Albert Square, Manchester. Film, "The Failure of the Tacoma Narrows Bridge." 2.30 p.m.

Institution of Electrical Engineers

Friday, Jan. 2nd.—METER AND INSTRUMENT SECTION: Savoy Place, Victoria Embankment, W.C.2. "The Electrostatic Voltmeter as a D.C./A.C. Transfer Instrument," R. S. J. Spilsbury and A. Felton. 5 p.m.

Institution of Mechanical Engineers

Friday, Jan. 9th.—Storey's Gate, Westminster, S.W.1. "The Utilisation of Wood Refuse for Steam Raising," R. B. Gillham. 2.30 p.m.

Junior Institution of Engineers

Saturday, Jan. 3rd.—39, Victoria Street, S.W.1. "Some Technical Terms," J. Foster Petree. 2.30 p.m.

END OF VOL. CLXXII

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JAN 26 1942

With METALLURGICAL SUPPLEMENT

The Engineer

VOL. CLXXII.—No. 4485 28, ESSEX ST., STRAND, LONDON, W.C.2 DECEMBER 26, 1941

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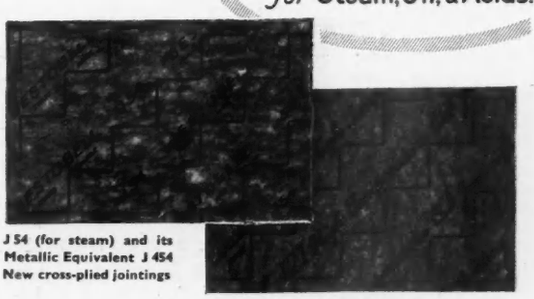

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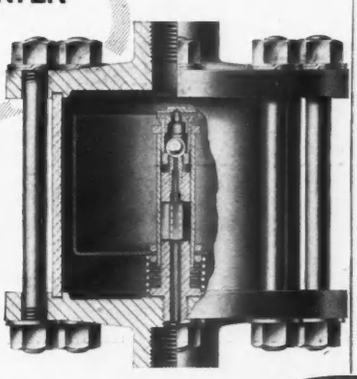

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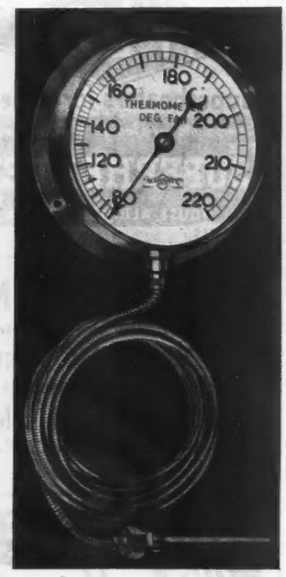

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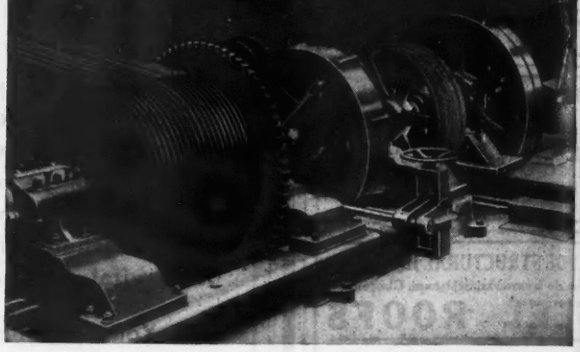

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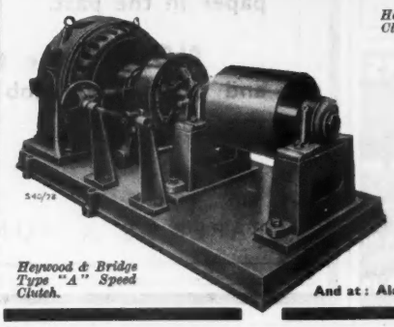

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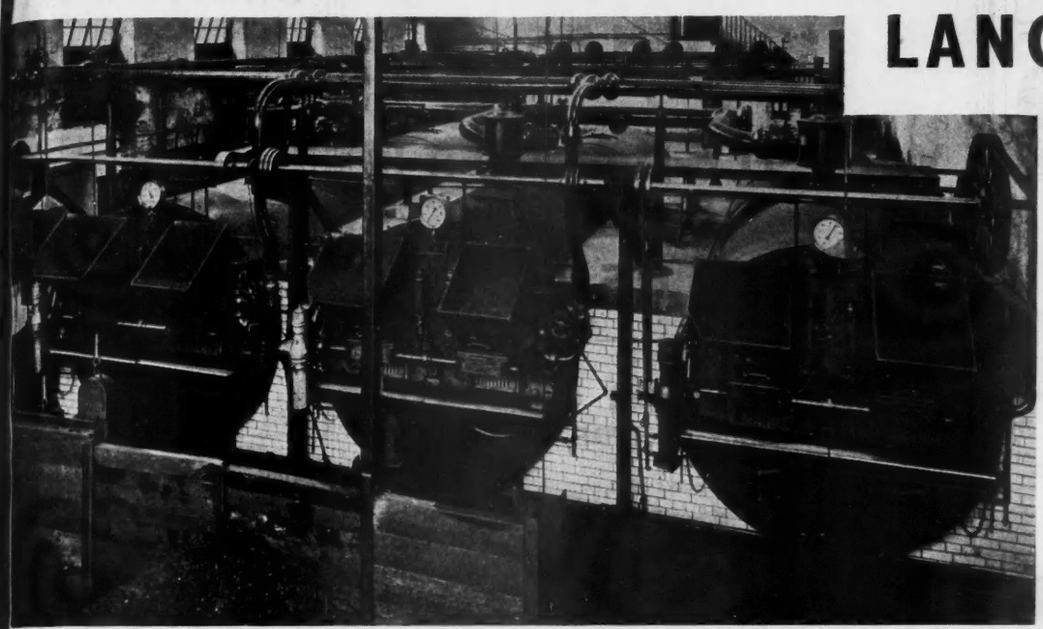

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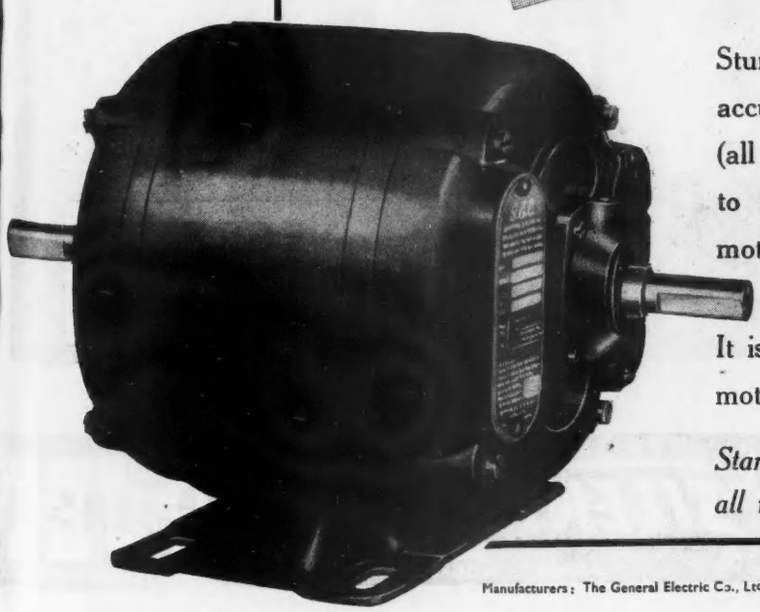

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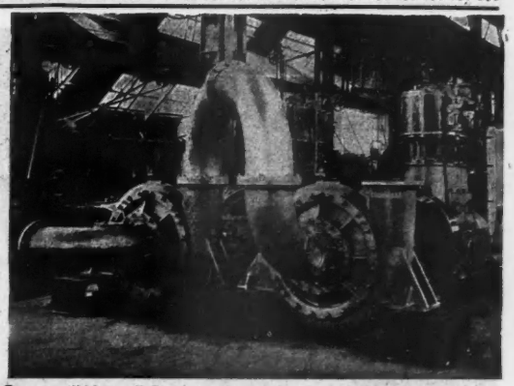

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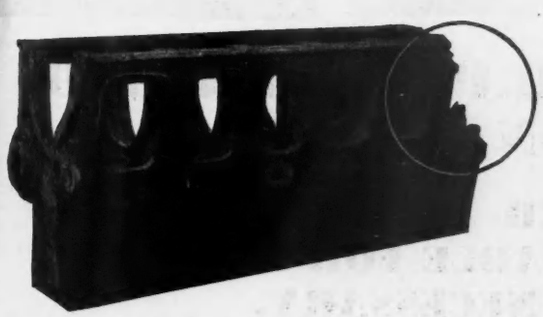
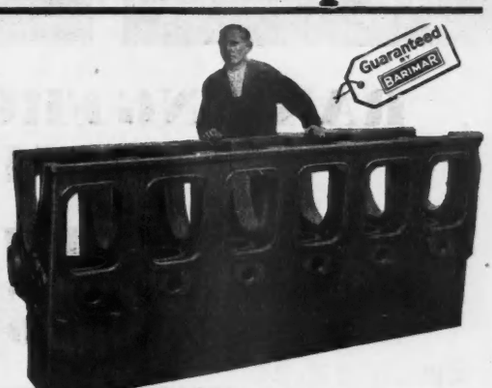


Left: Broken 5-ton Diesel engine crankcase. An easy job for Barimar. Right: Diesel engine crankcase repaired by Barimar, under the Barimar Money-Back Guarantee.



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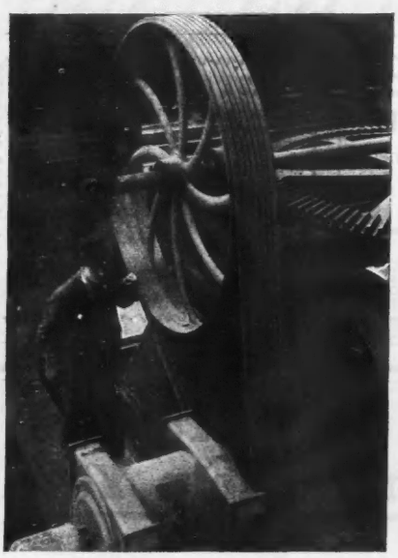

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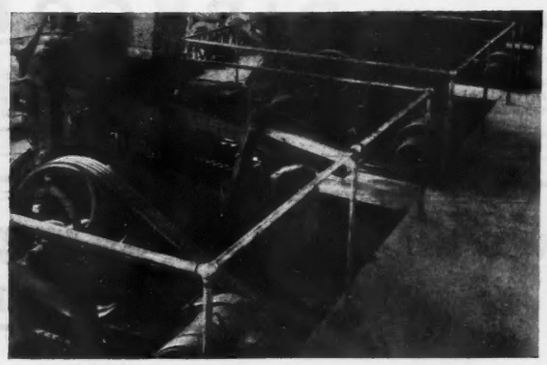

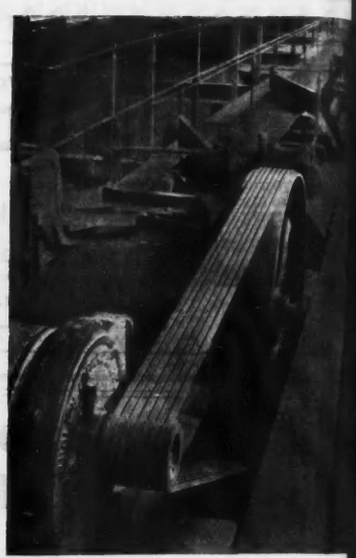

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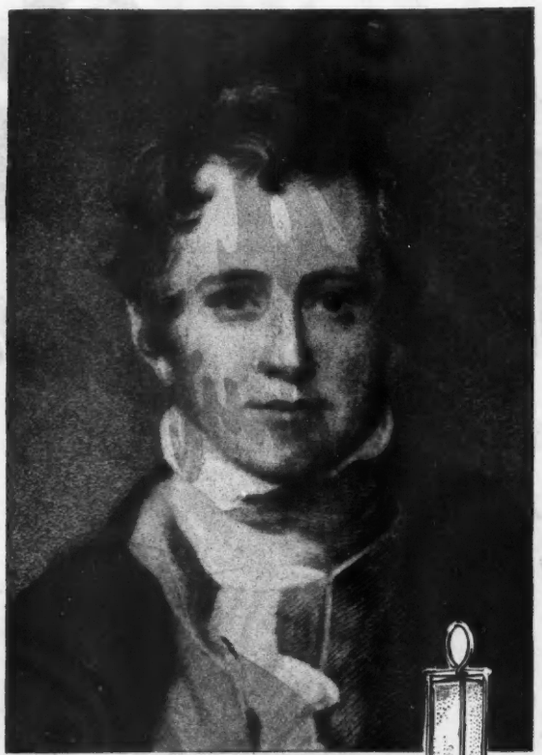
From a portrait by Sir Thomas Lawrence in the possession of the Royal Society.



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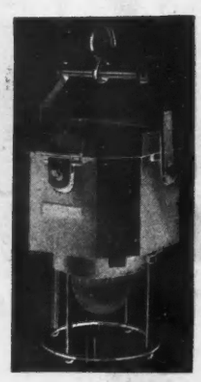

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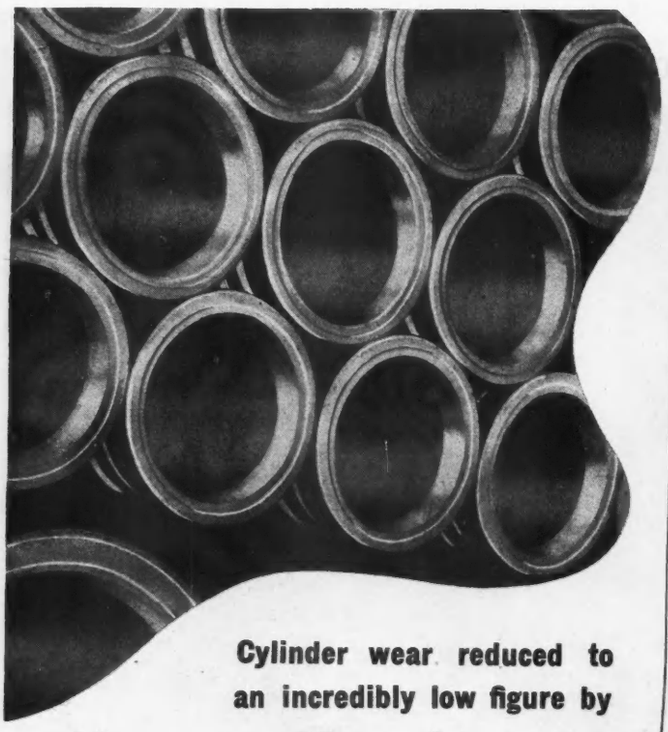

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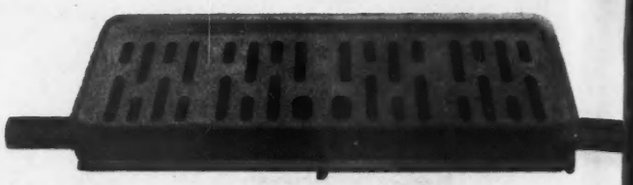

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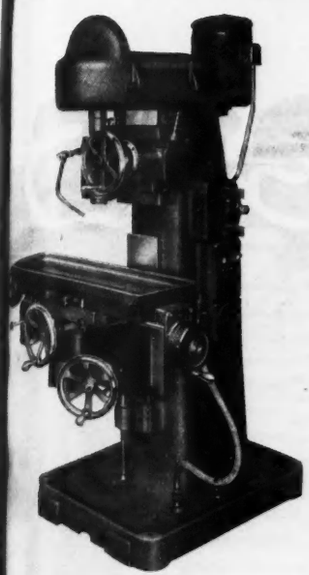

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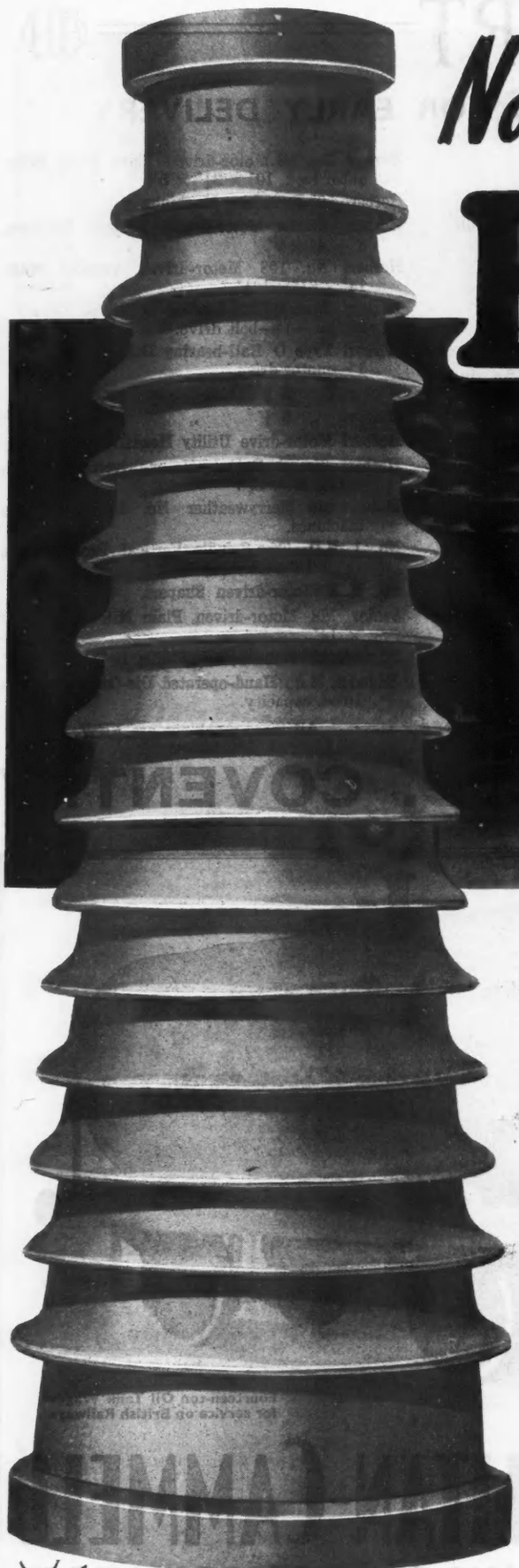

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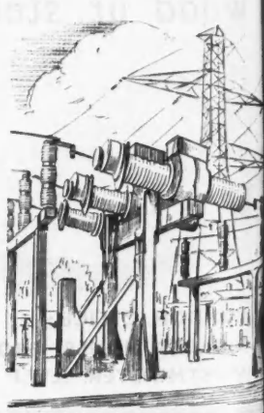

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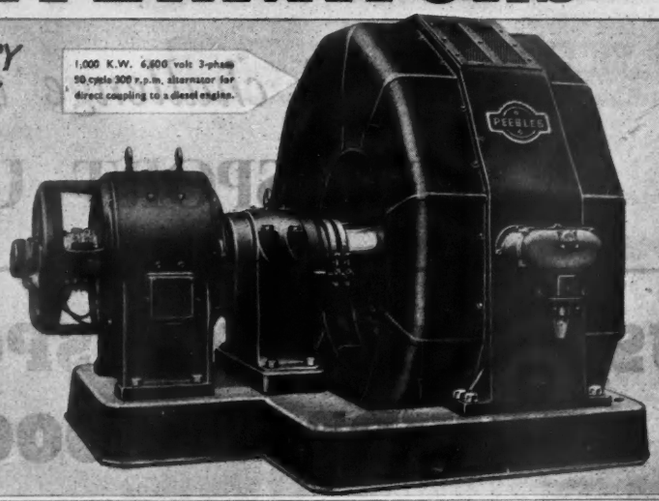

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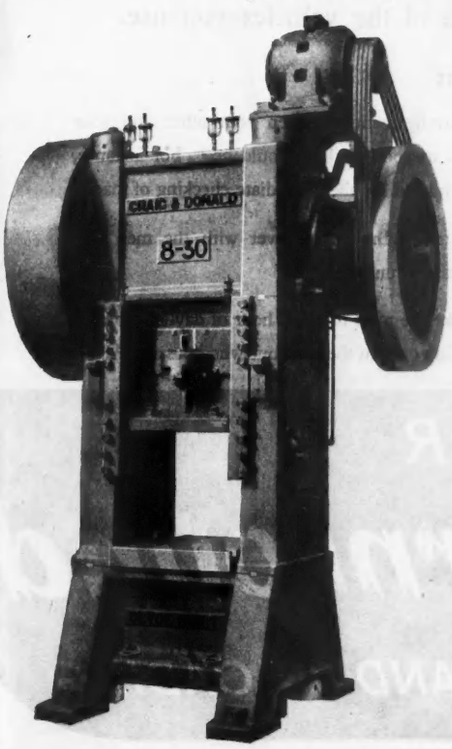

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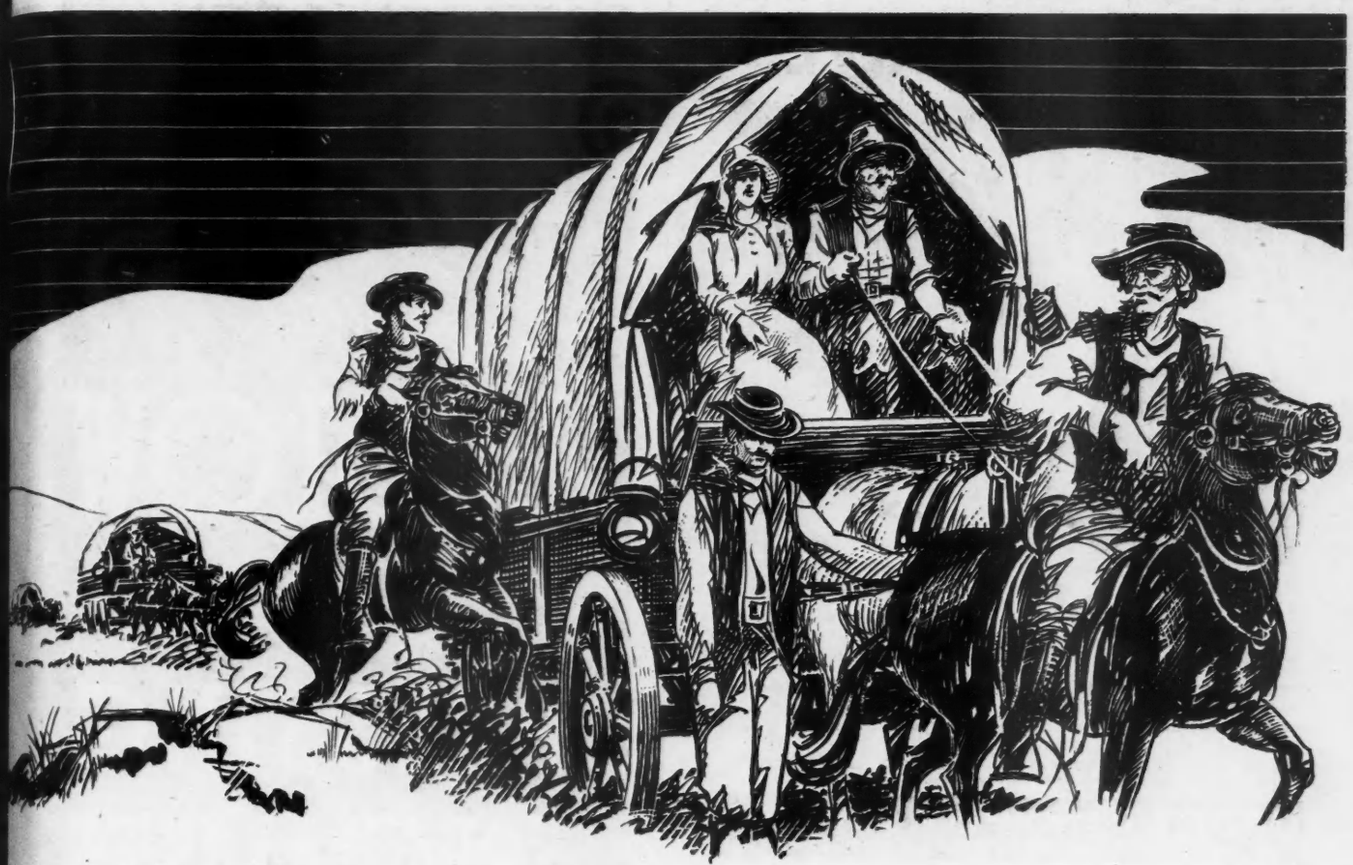

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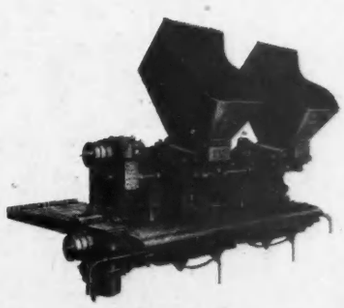

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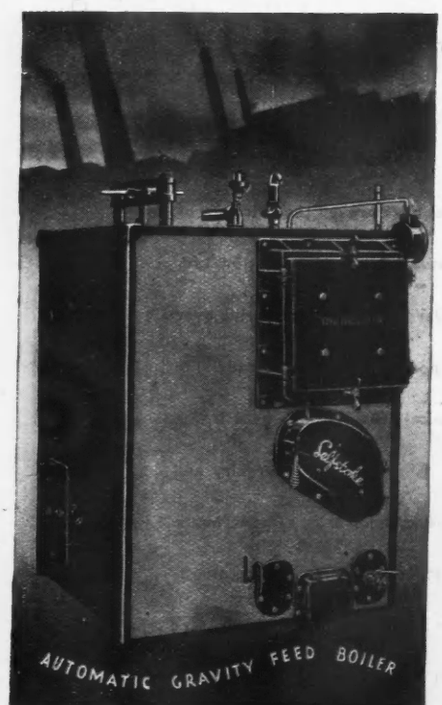

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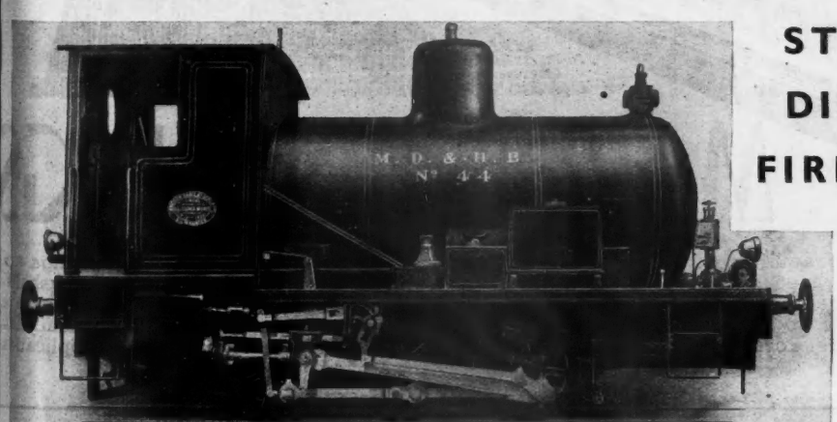

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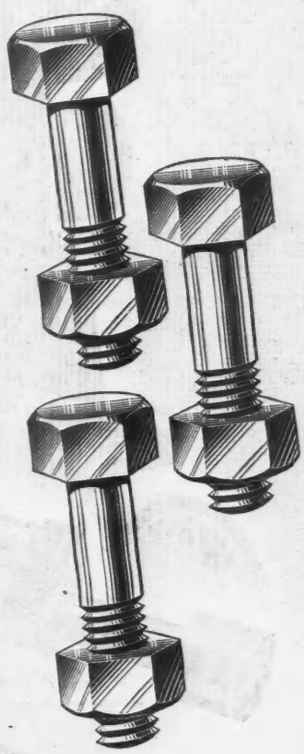

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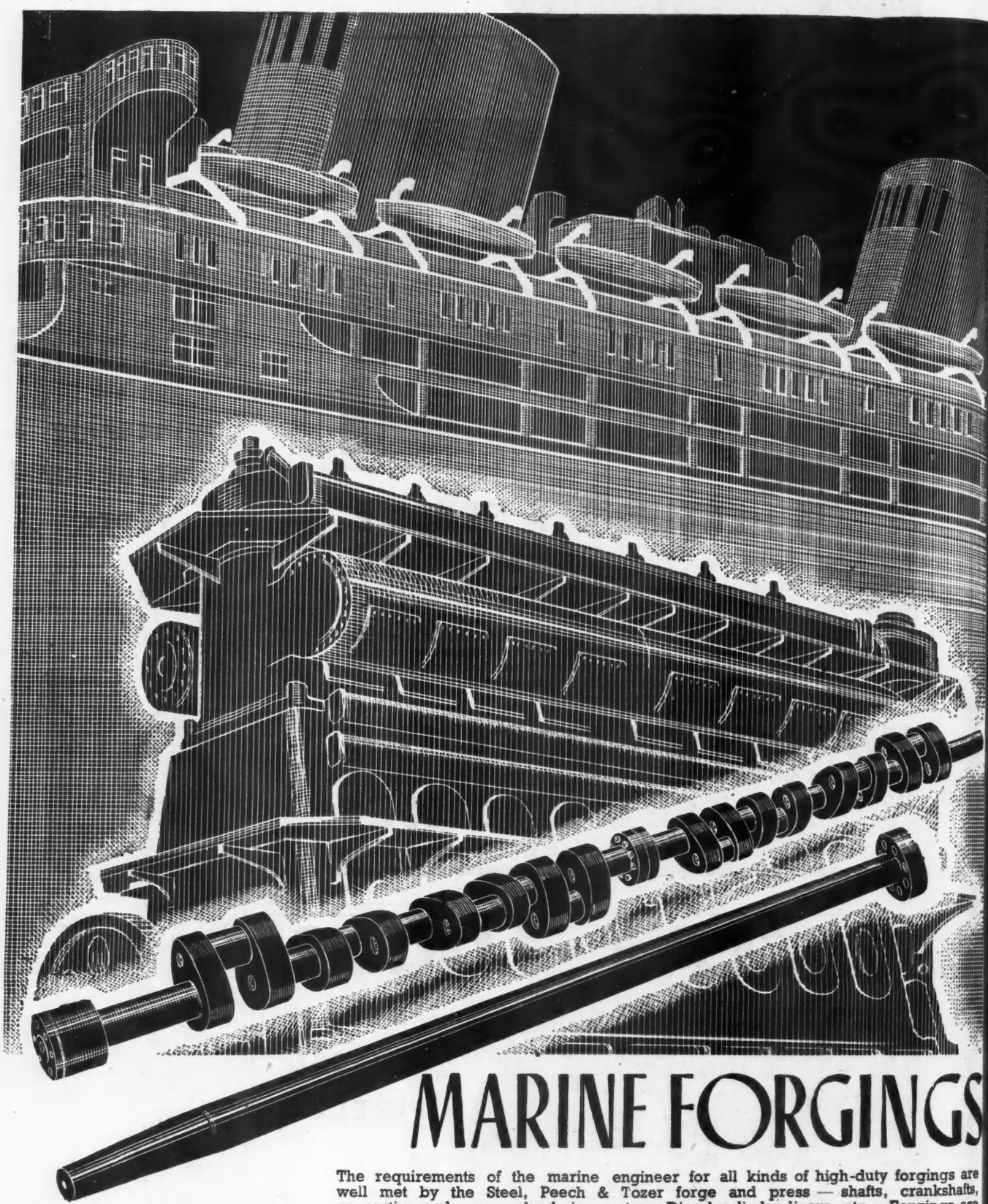

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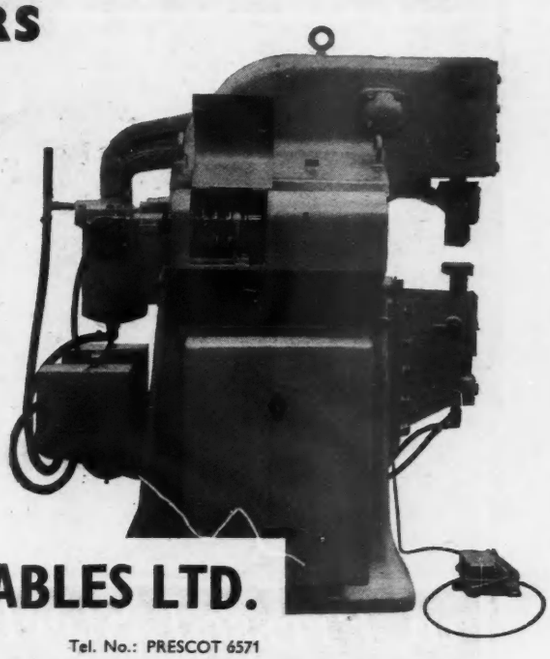

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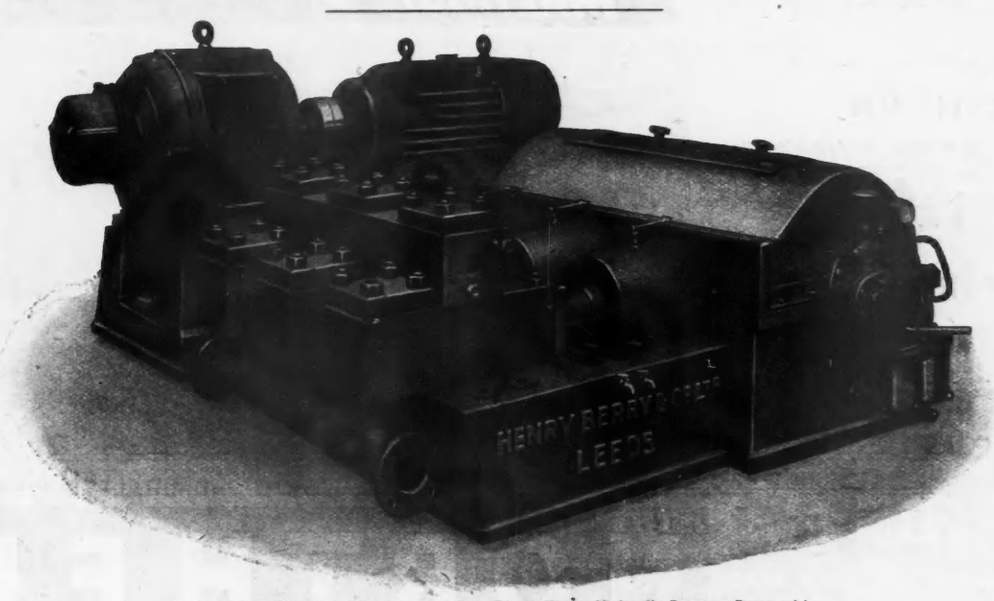

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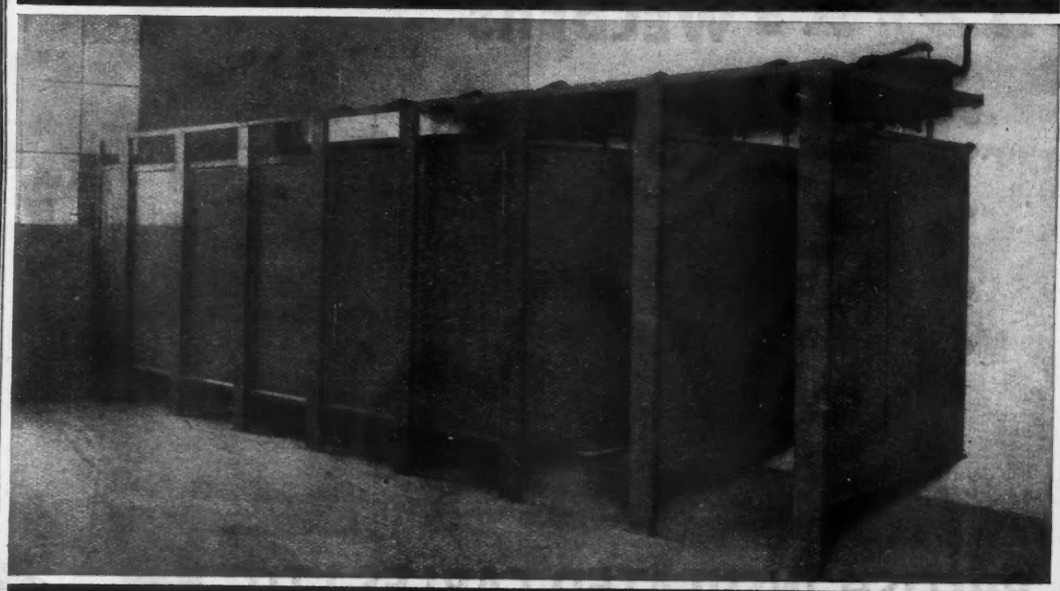

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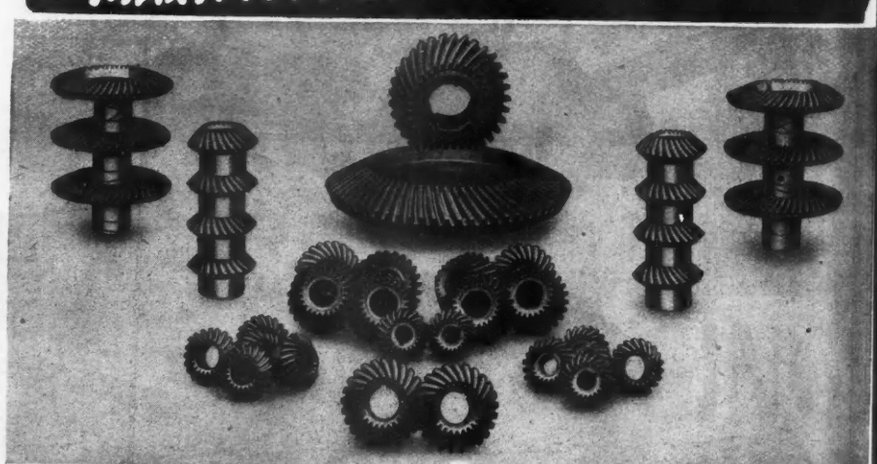

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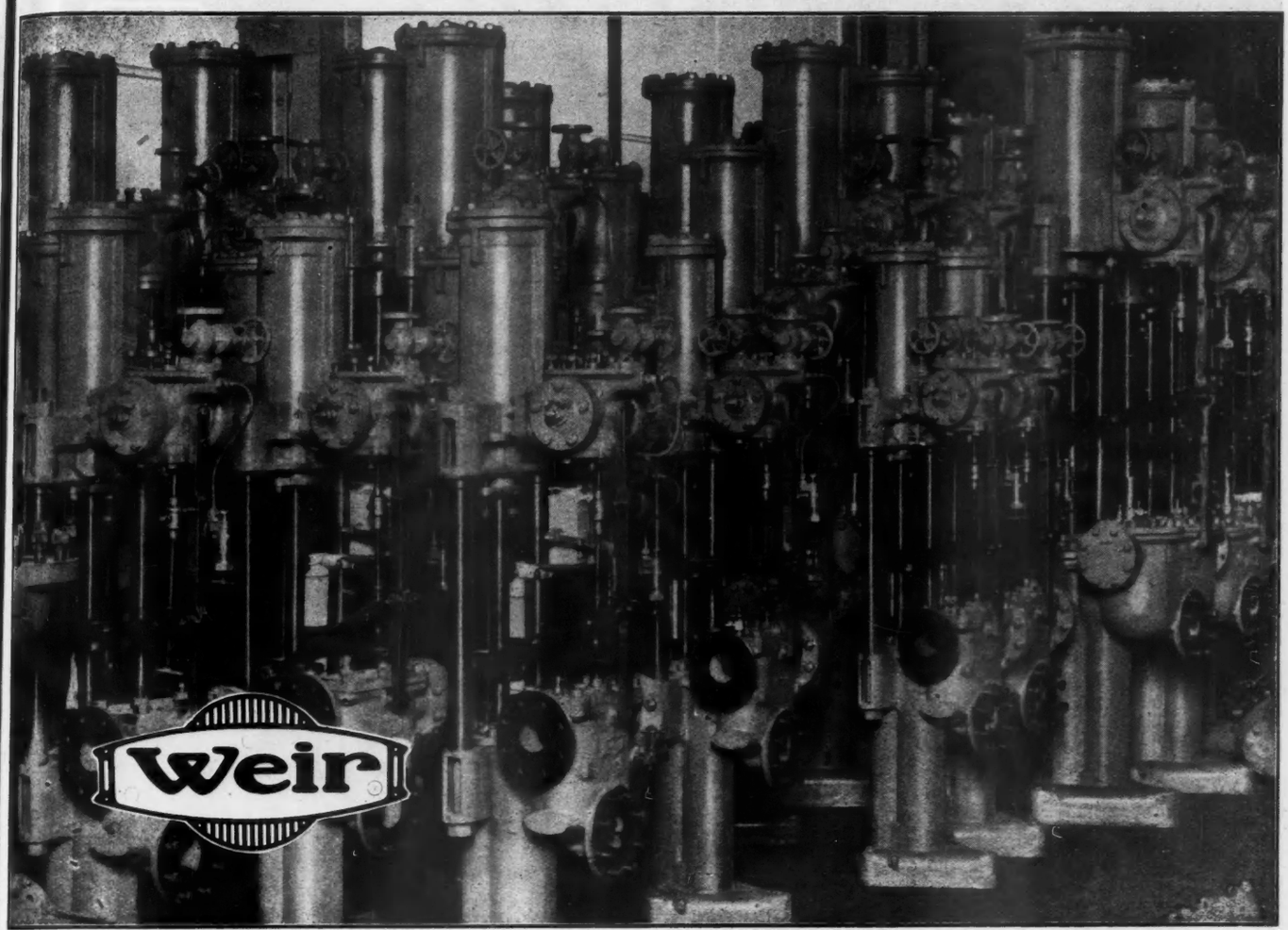

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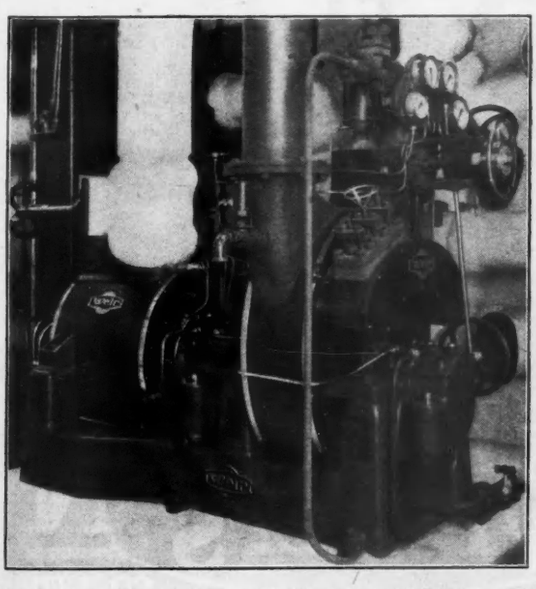

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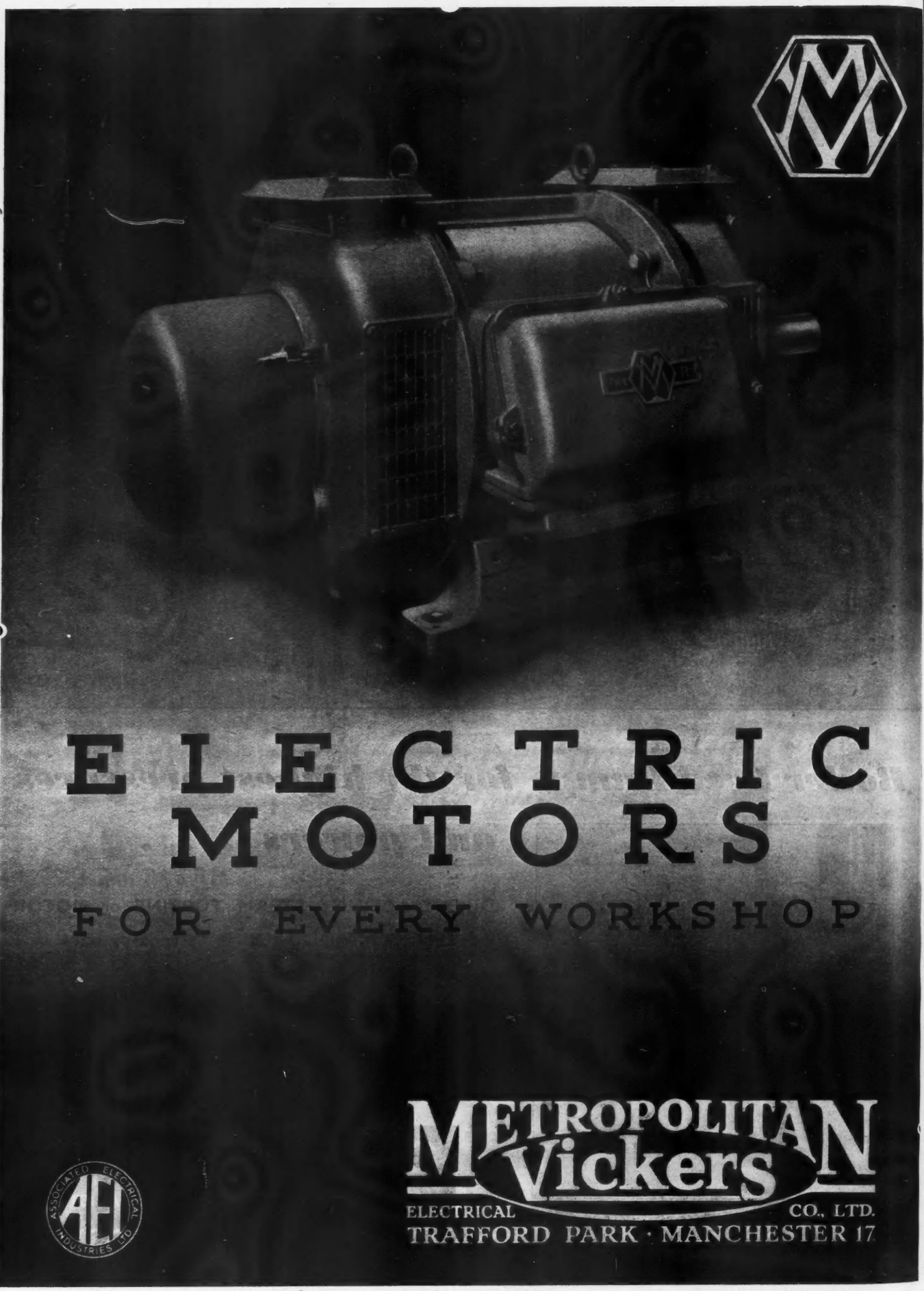
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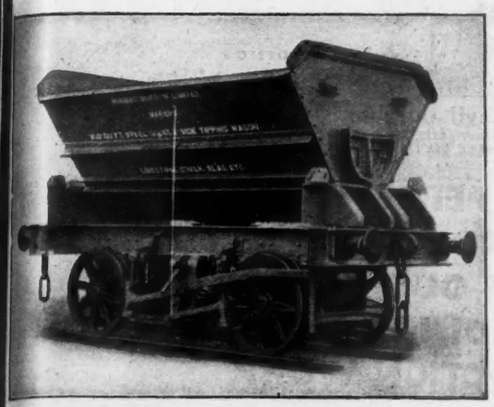

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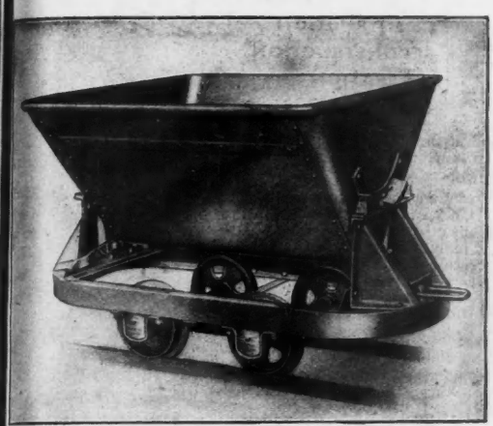

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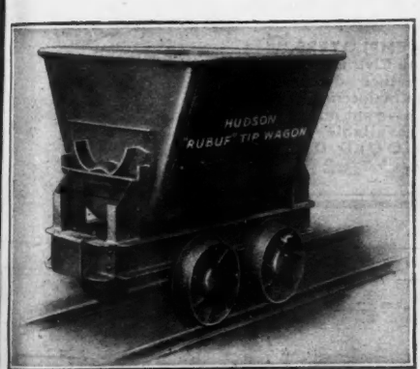

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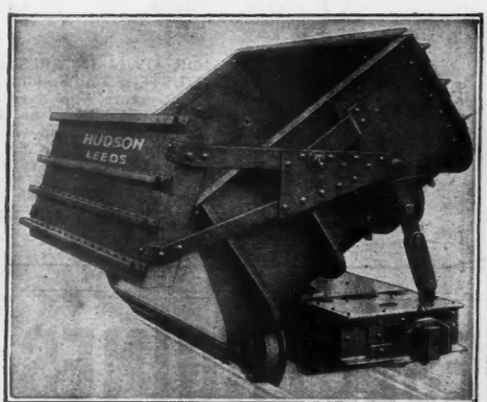

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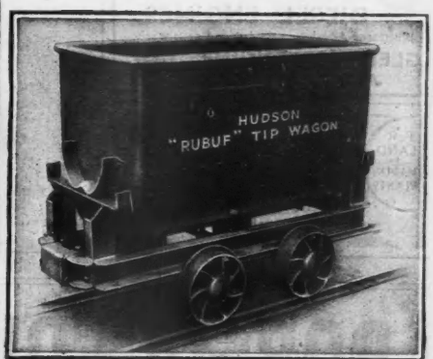

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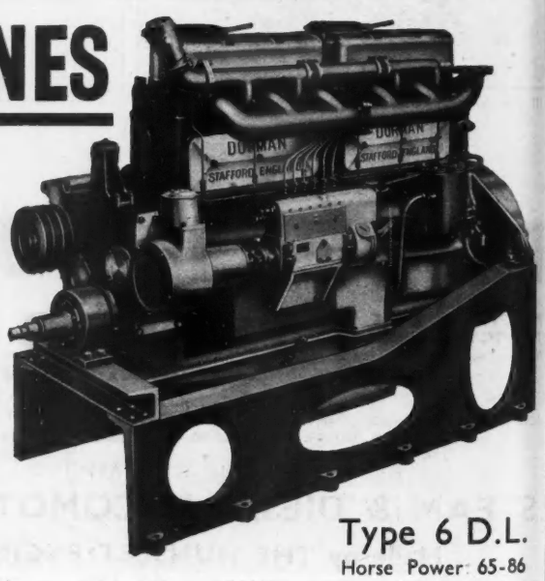

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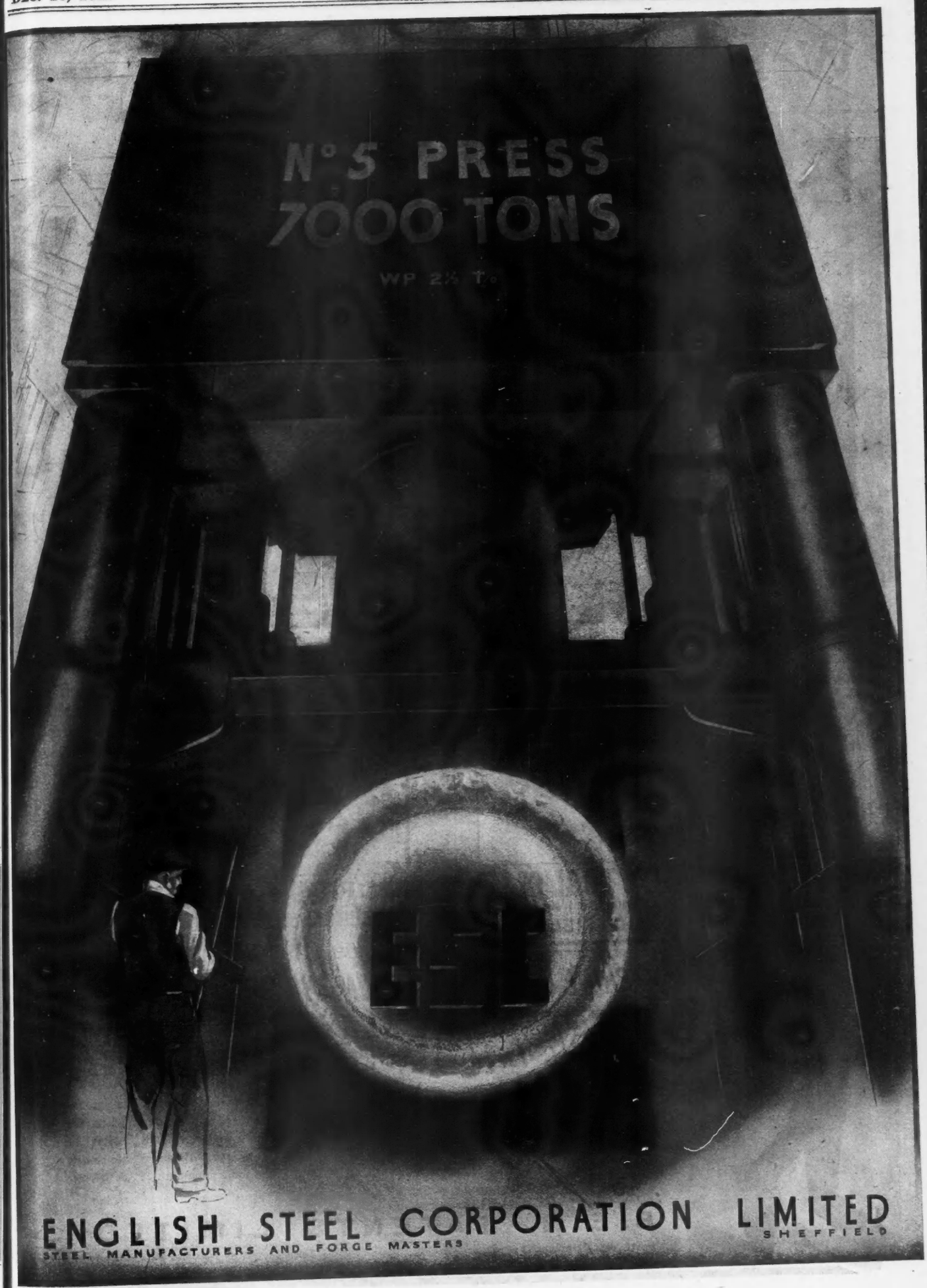
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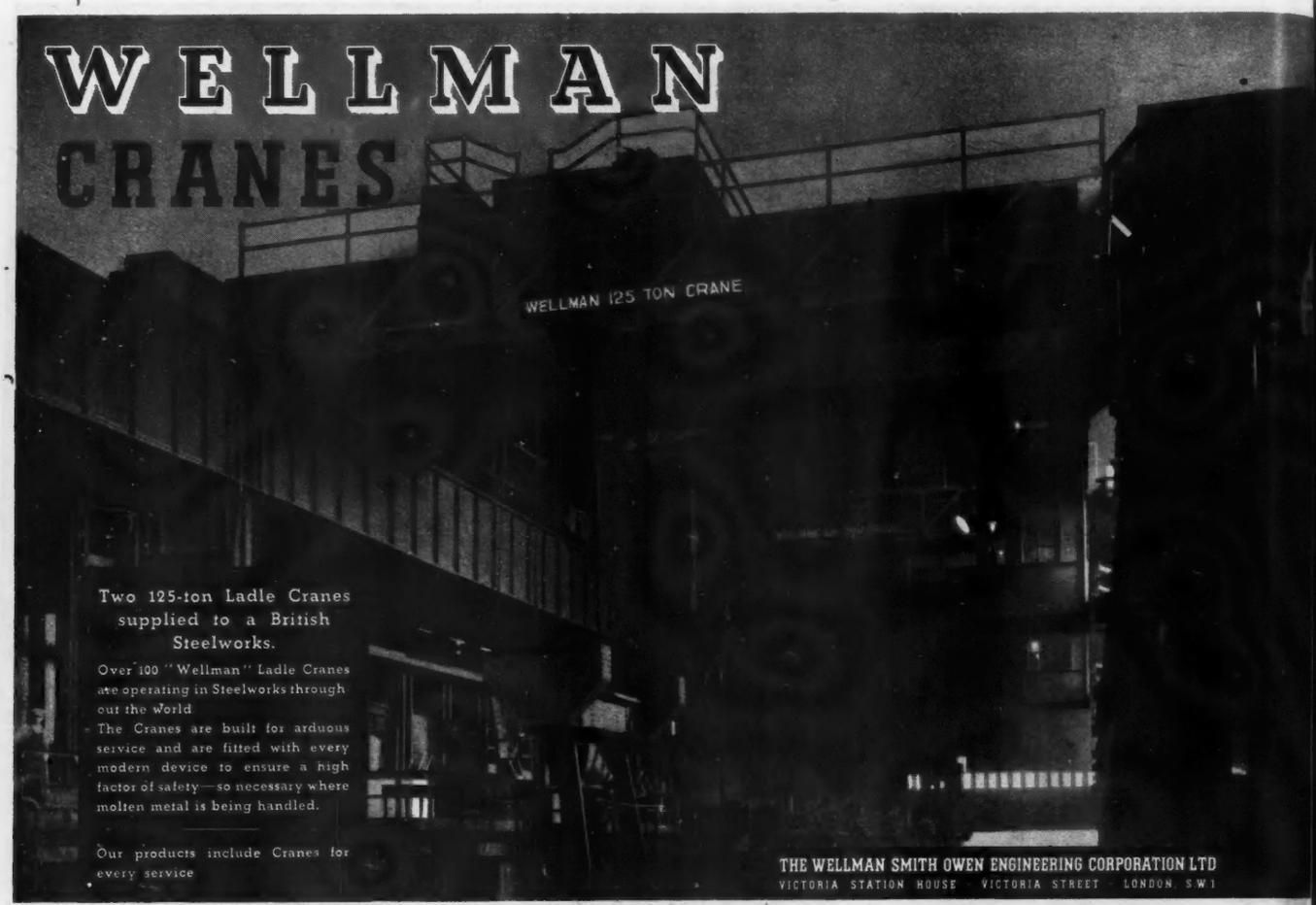

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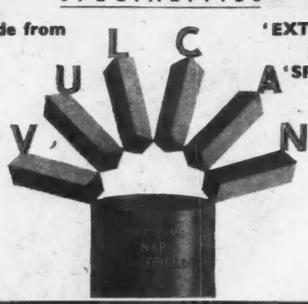

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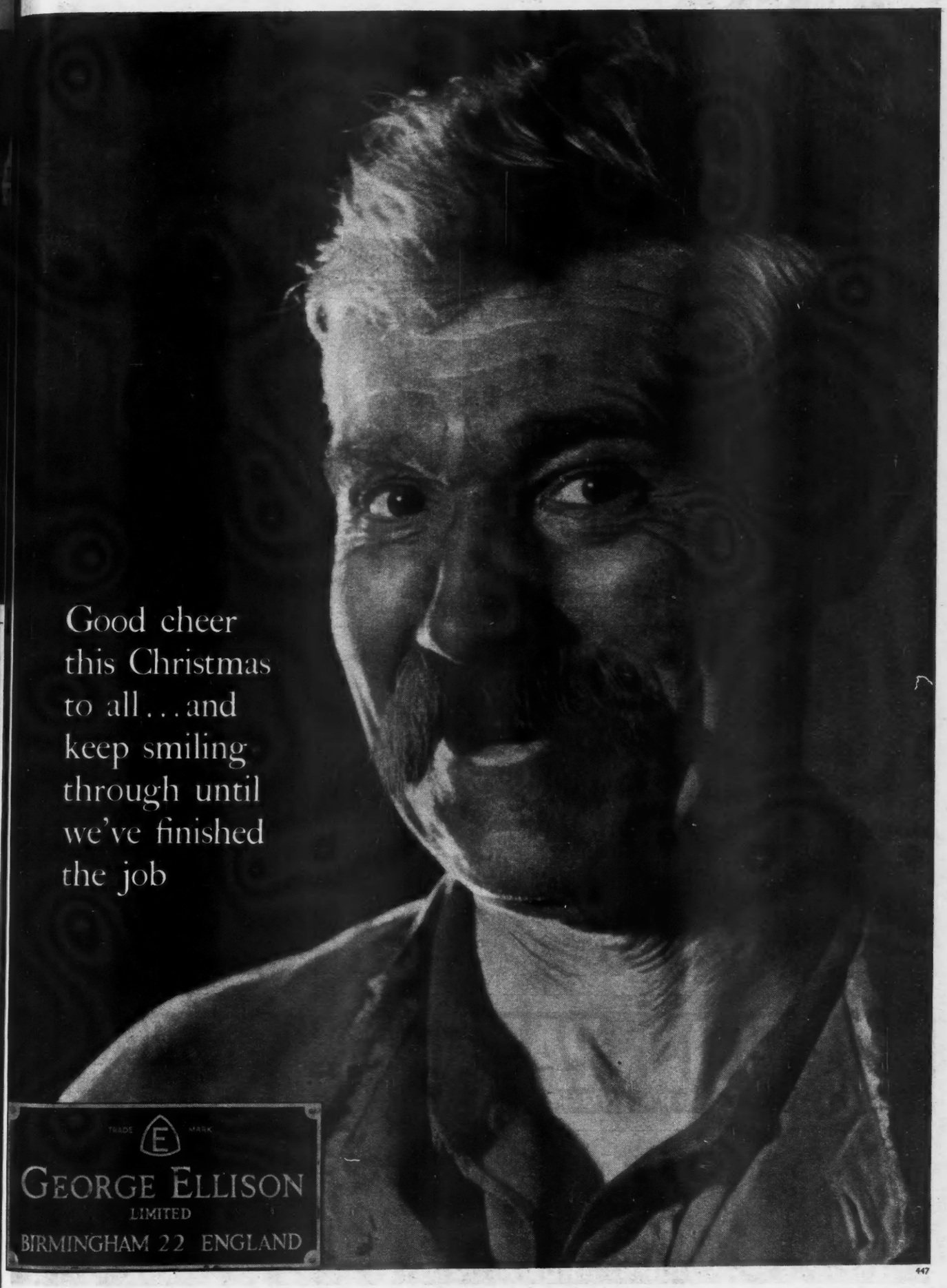
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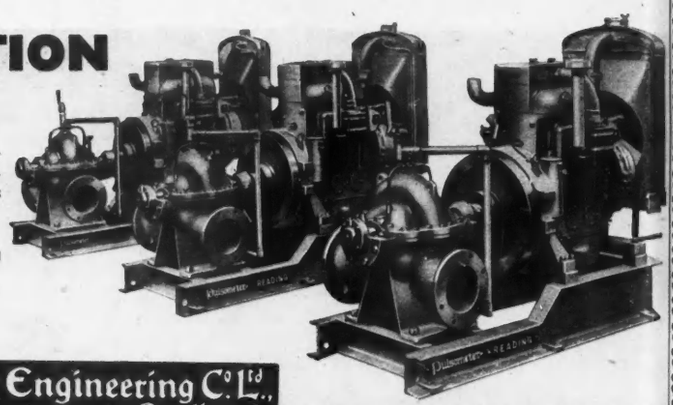

The illustration shows a set of three "Pulsometer" H.S. Split Casing Centrifugal Pumps supplied for irrigation in Egypt.

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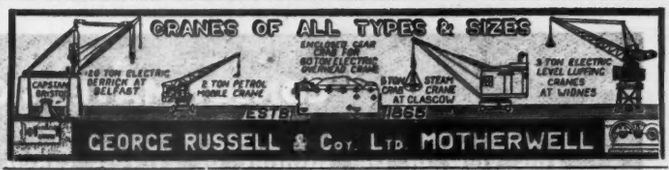
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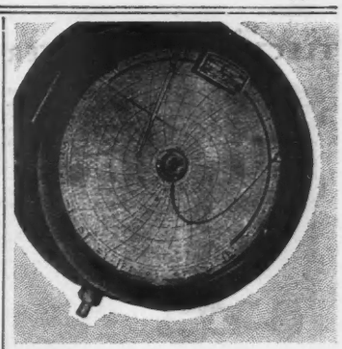

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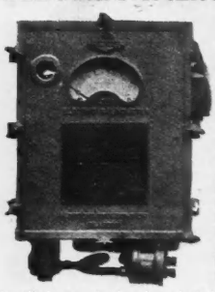

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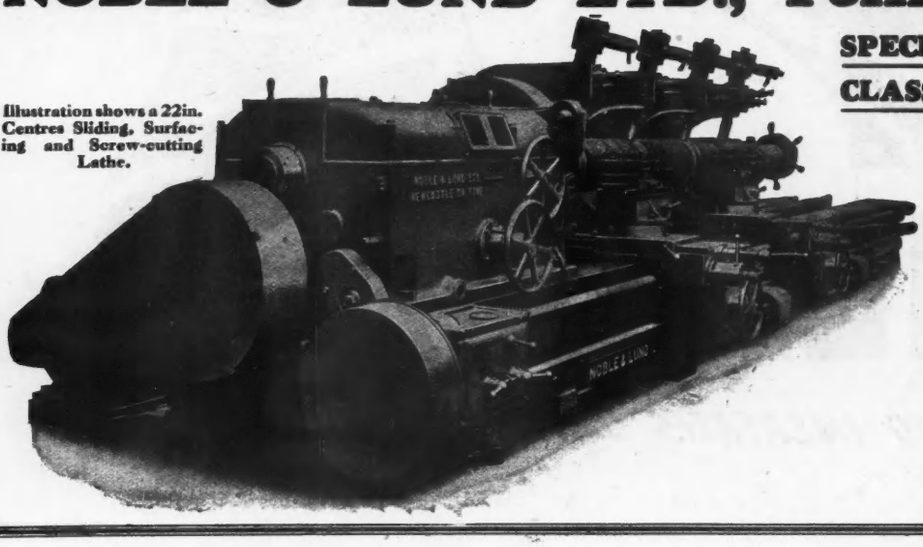

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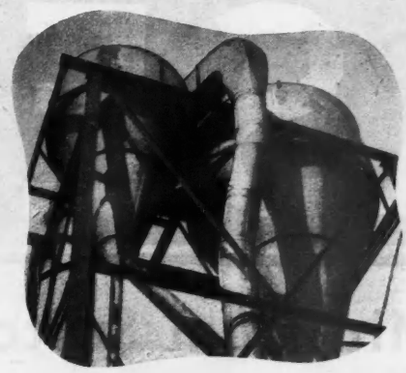

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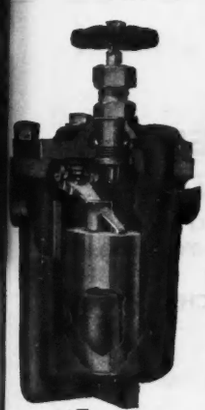

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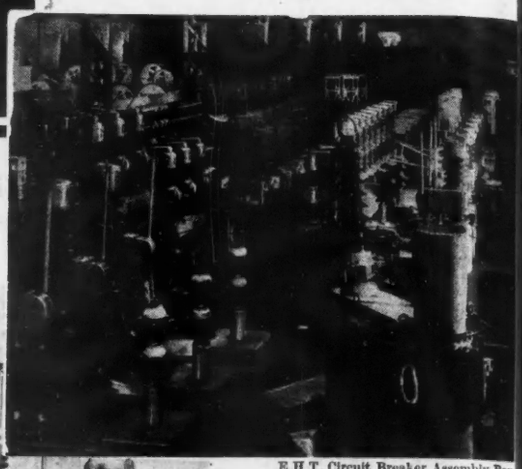
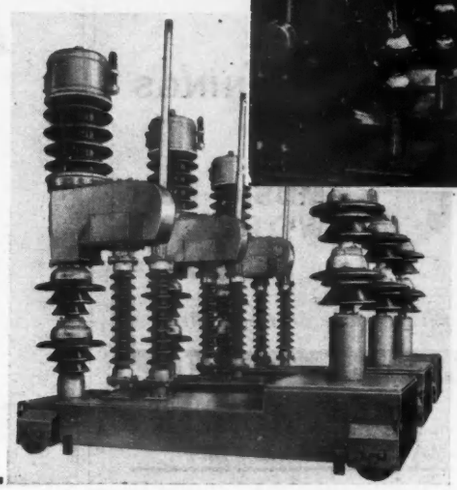


E.H.T. Circuit Breaker Assembly Bay



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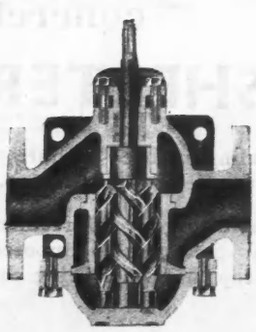

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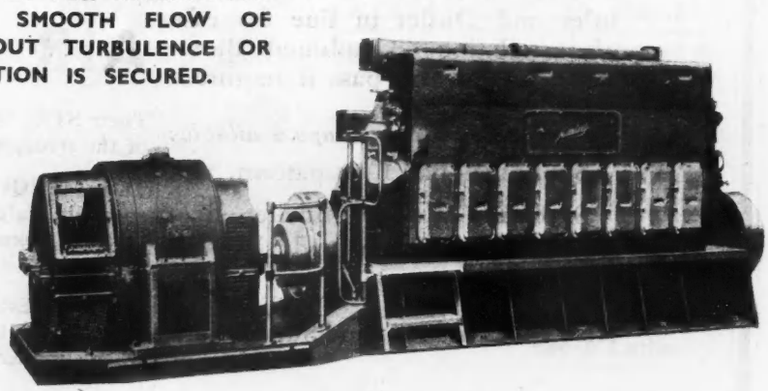

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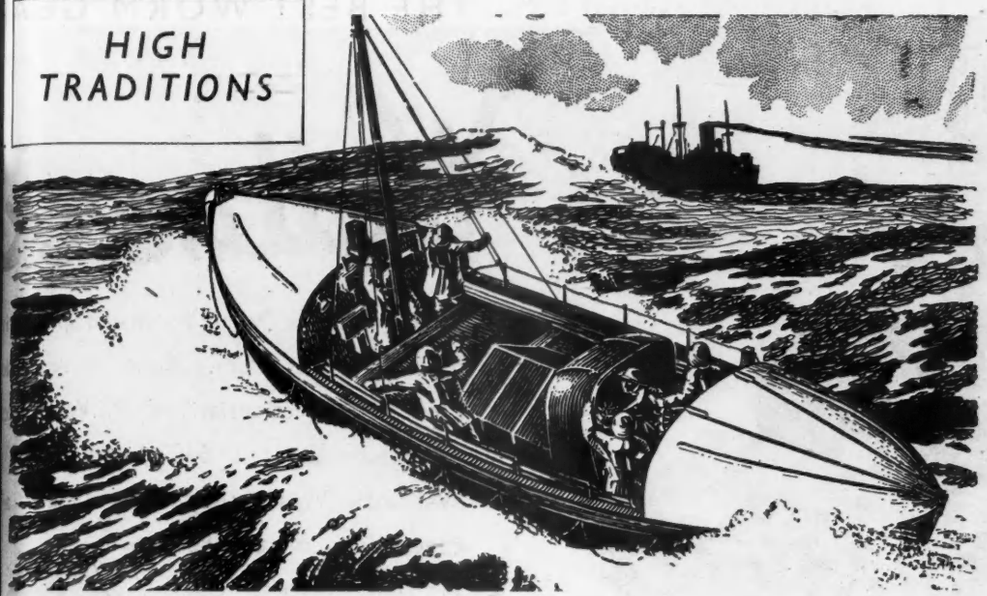

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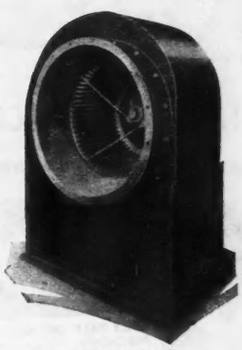

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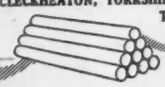

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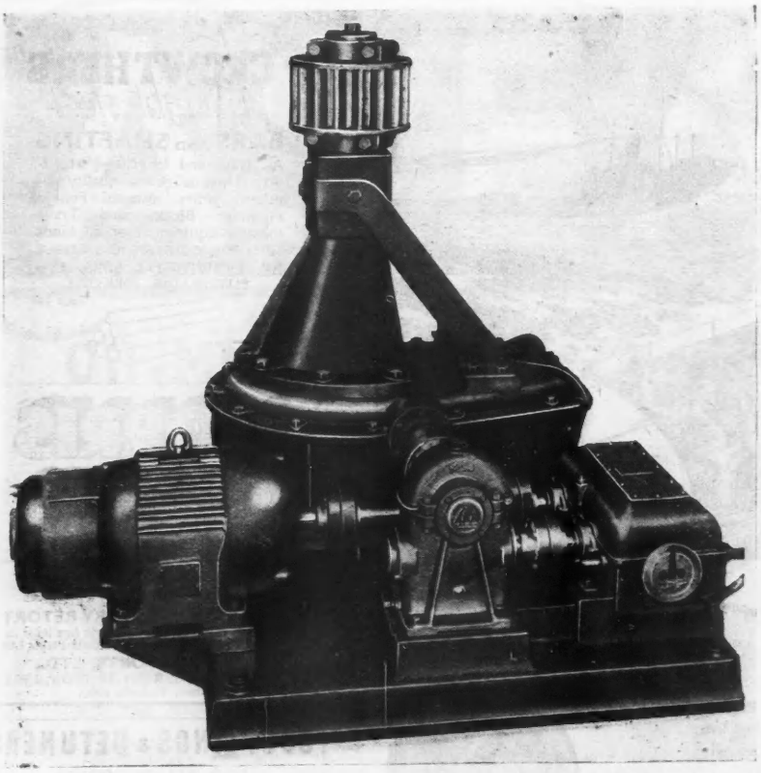

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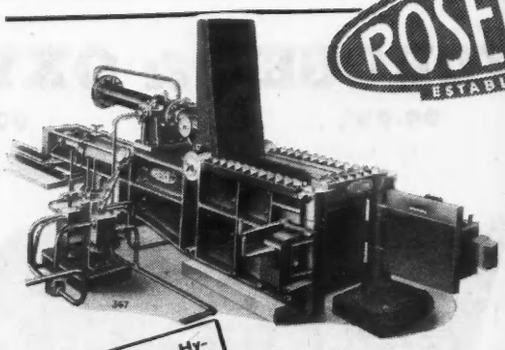
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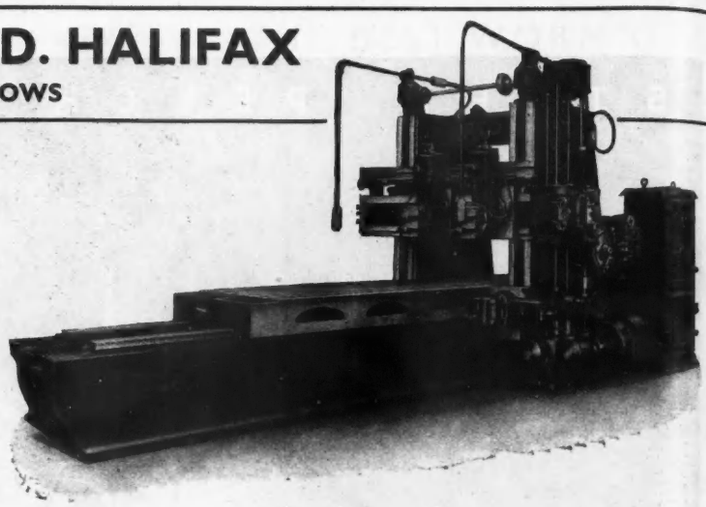

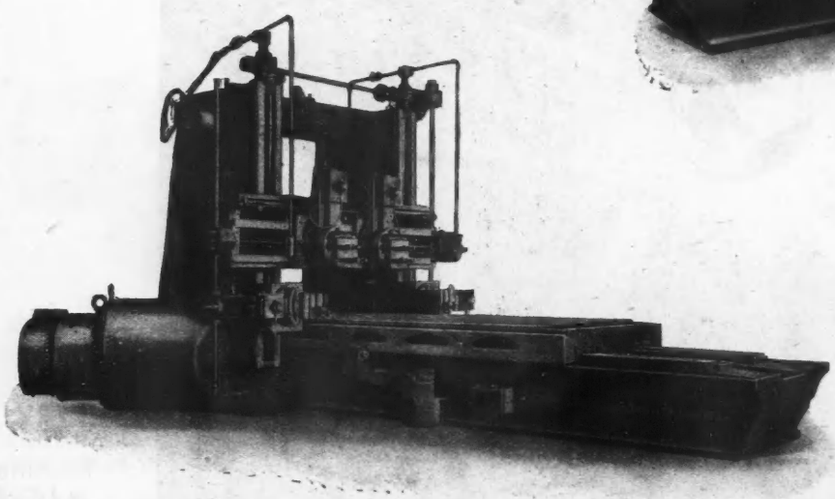

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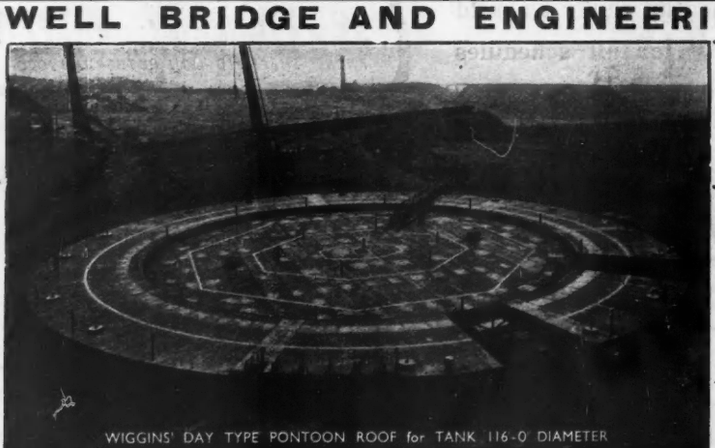

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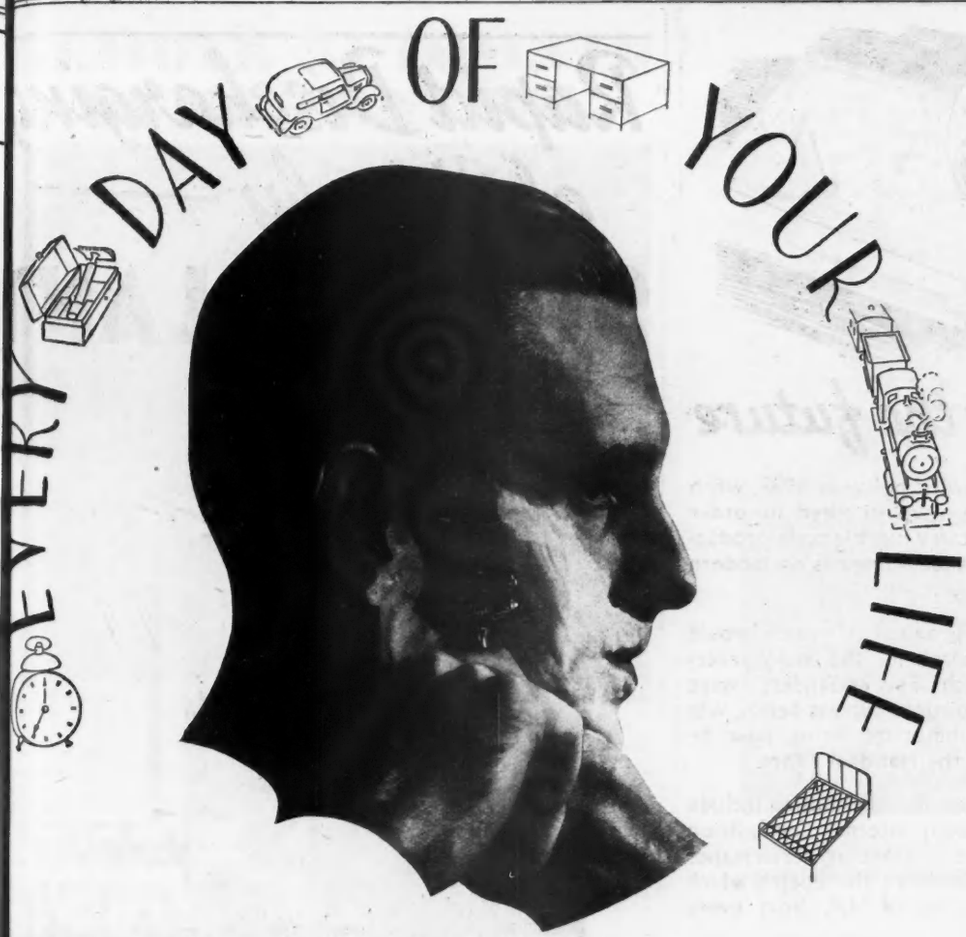

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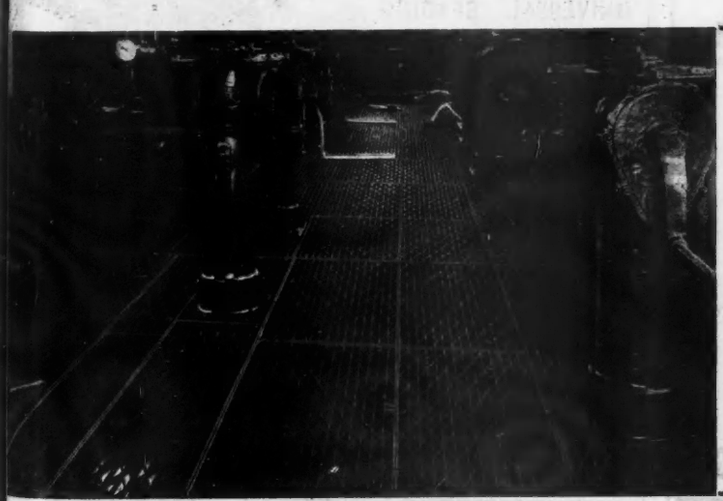

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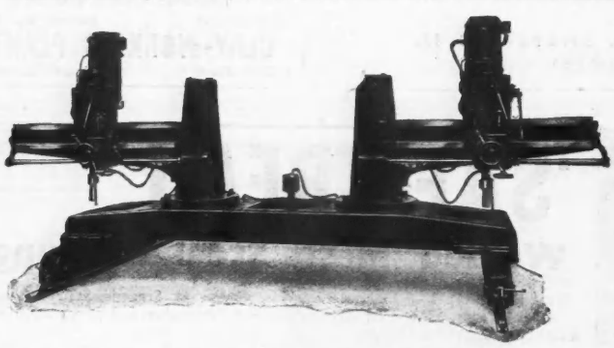

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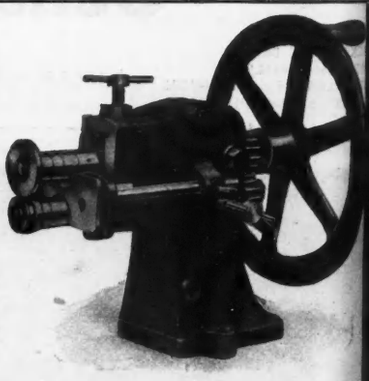

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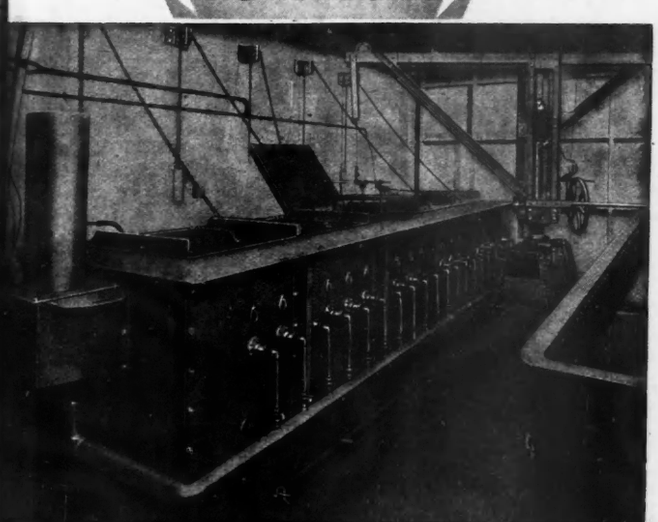

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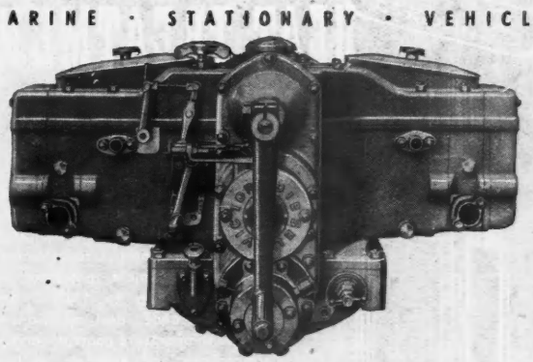

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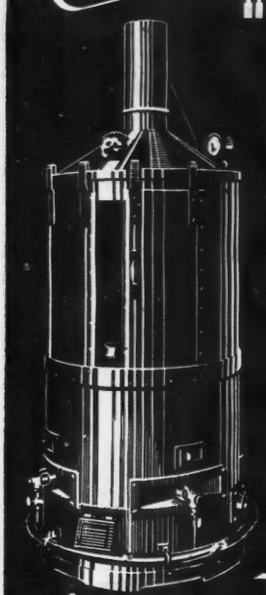

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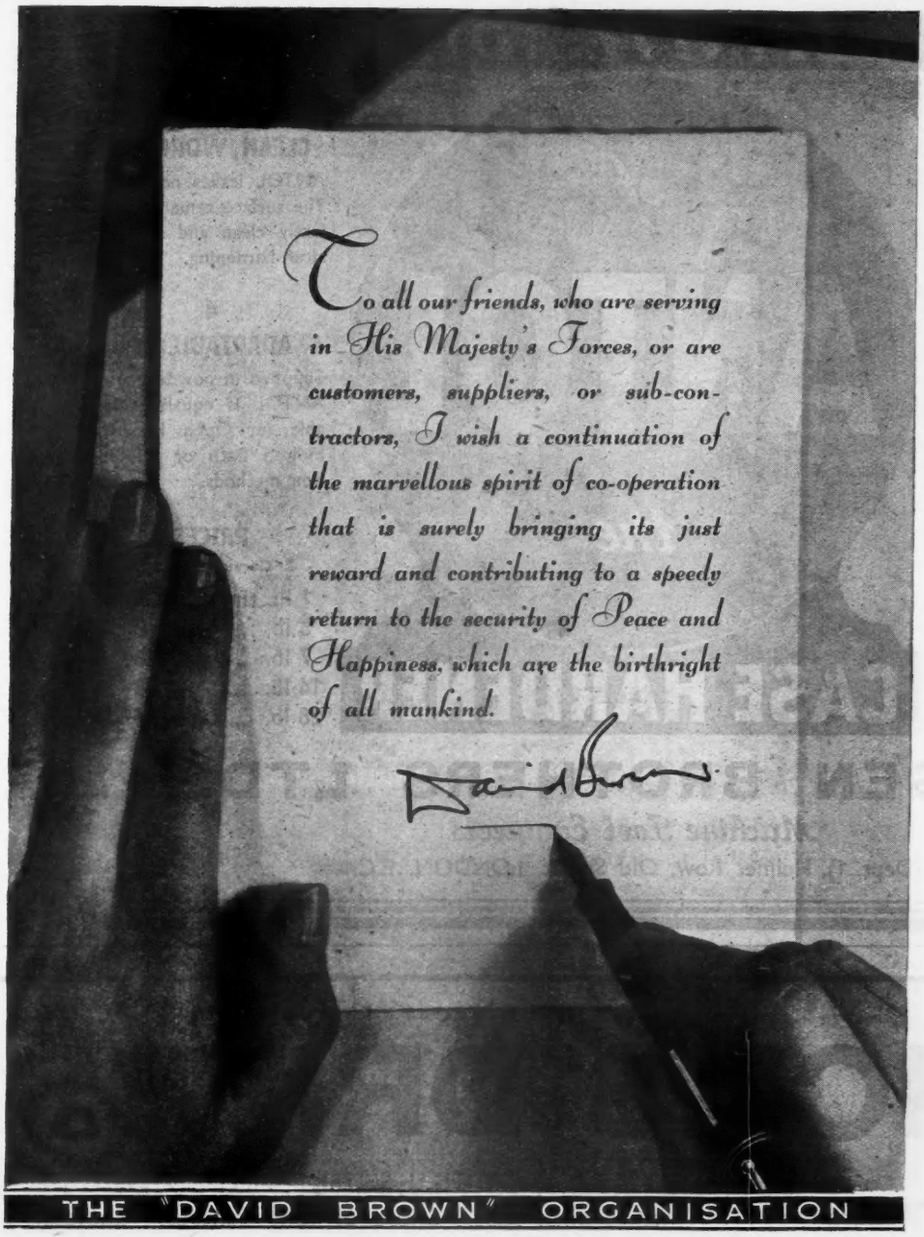
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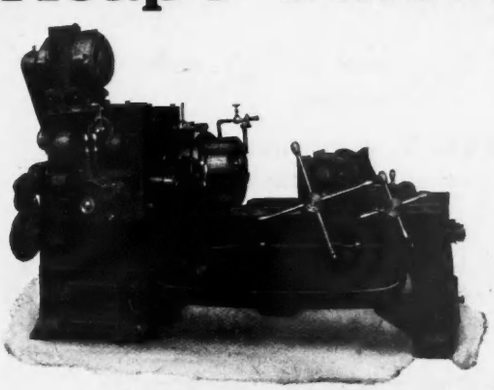

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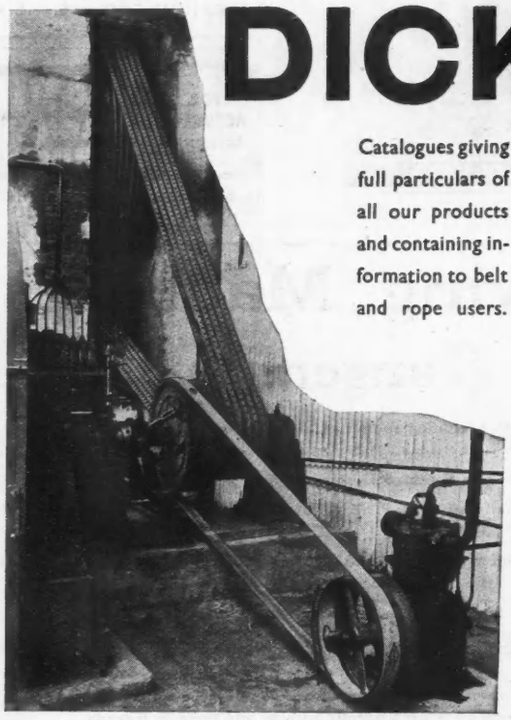

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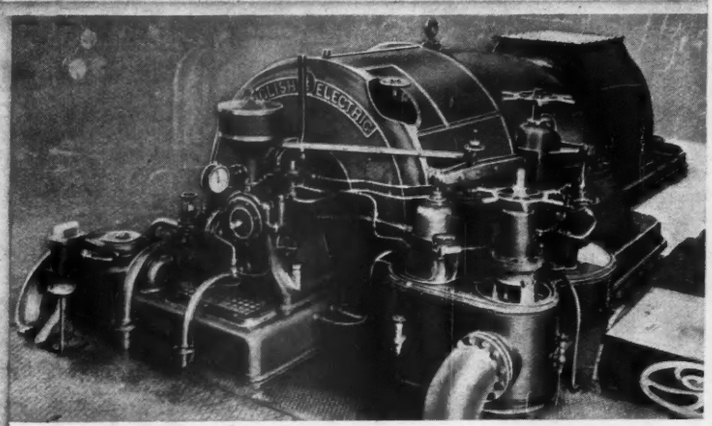

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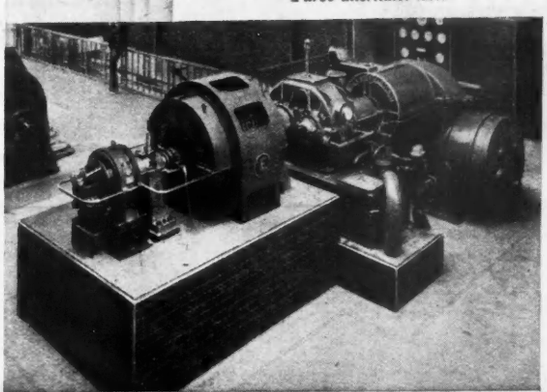

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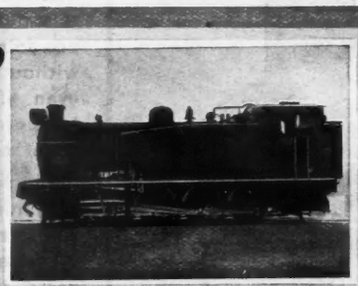

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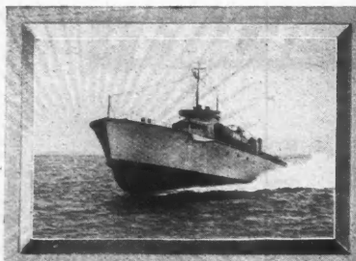
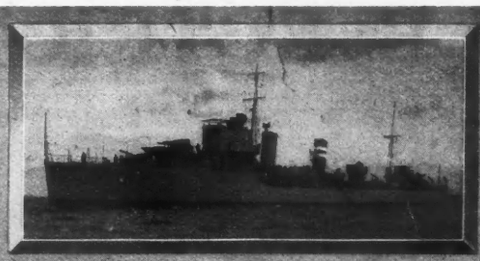
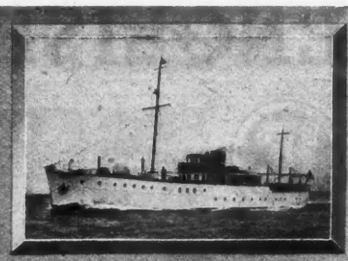

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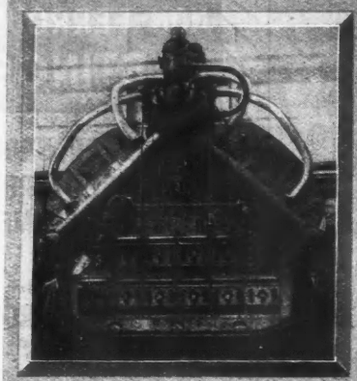
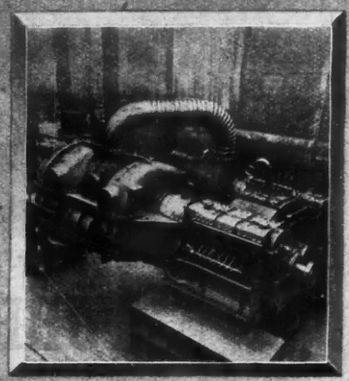

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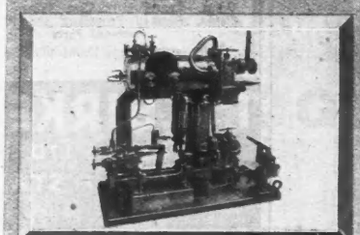

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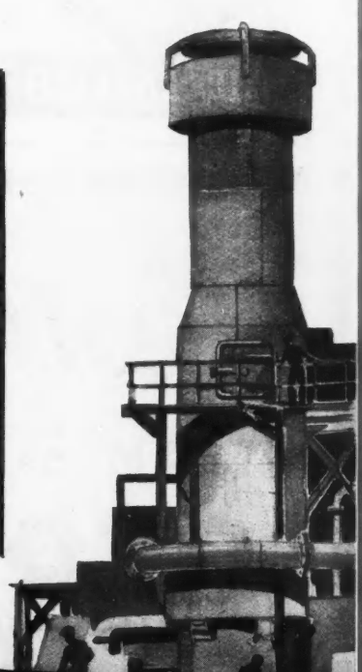

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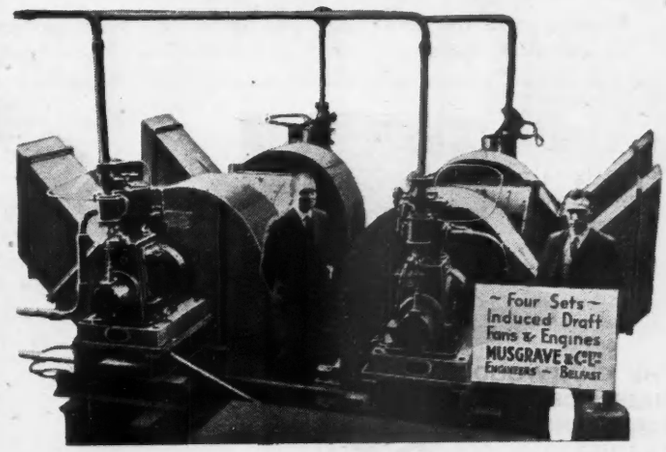

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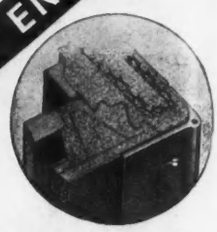

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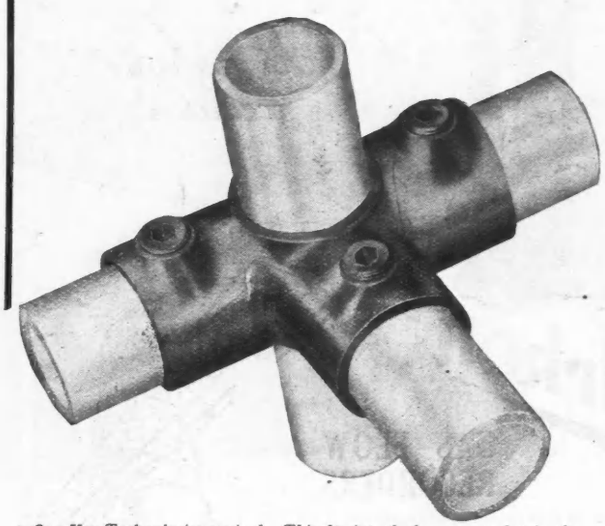

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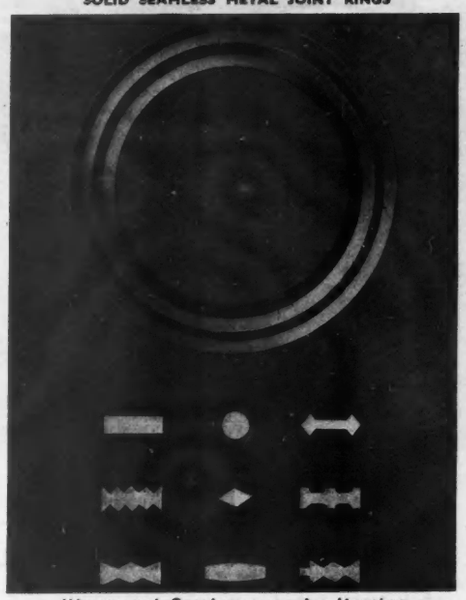

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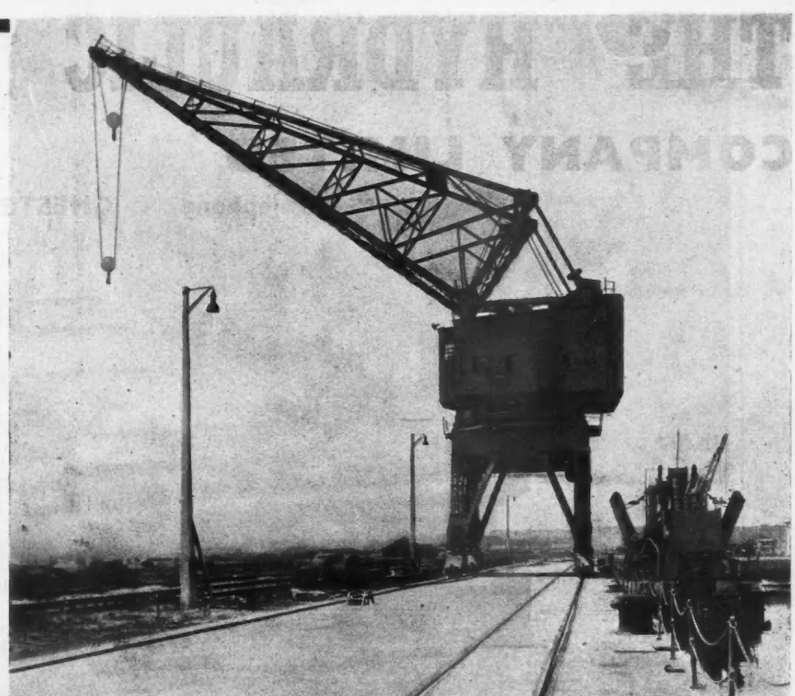

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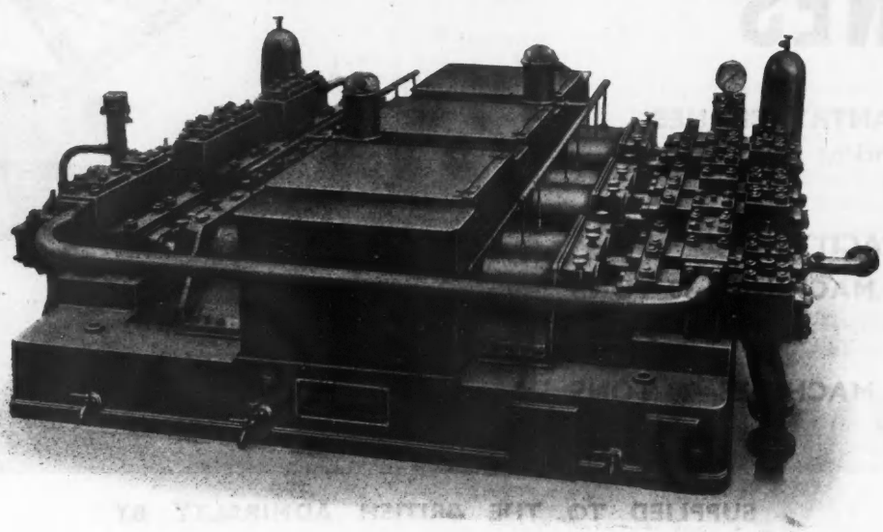

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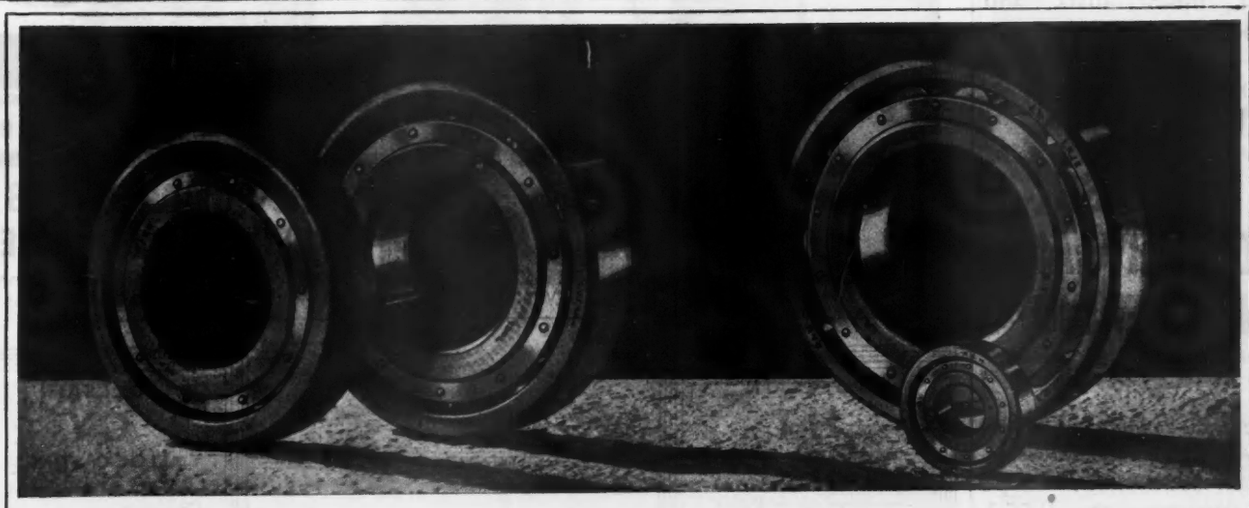

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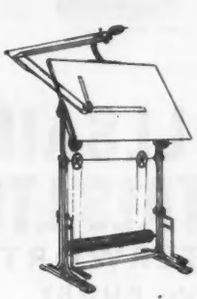

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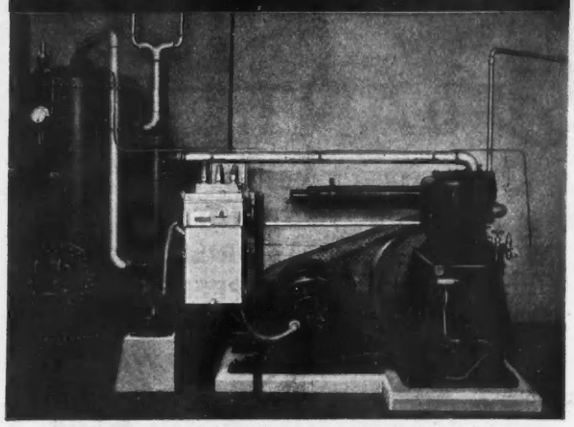

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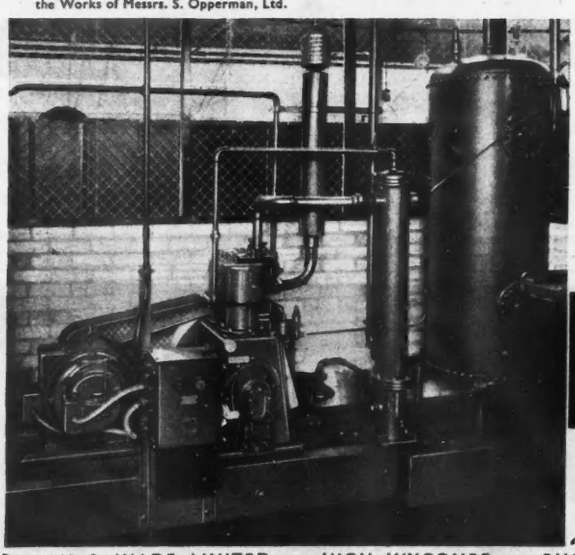

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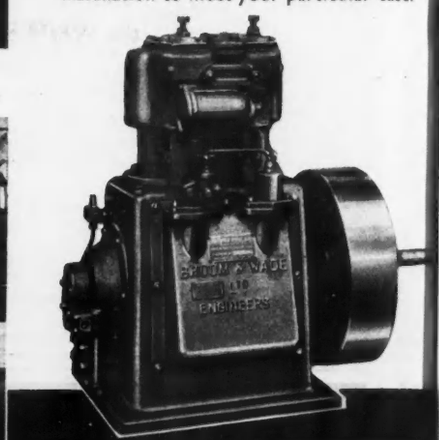

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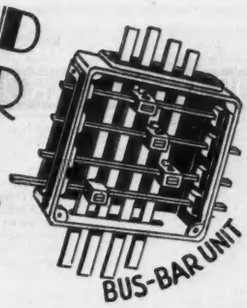

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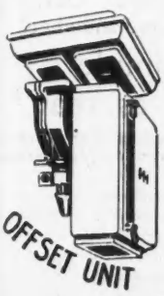

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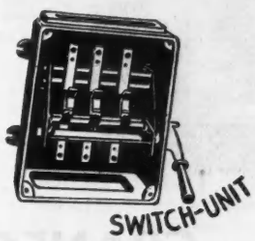

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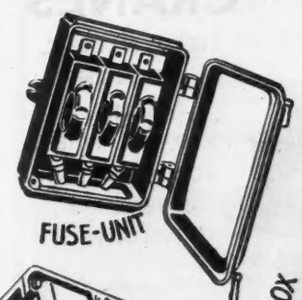

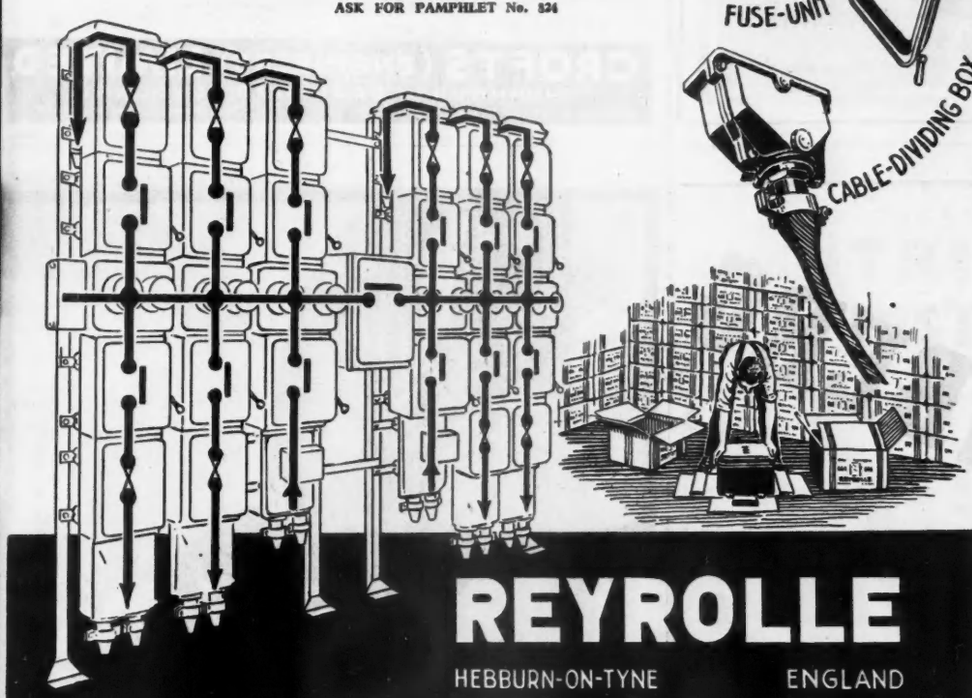

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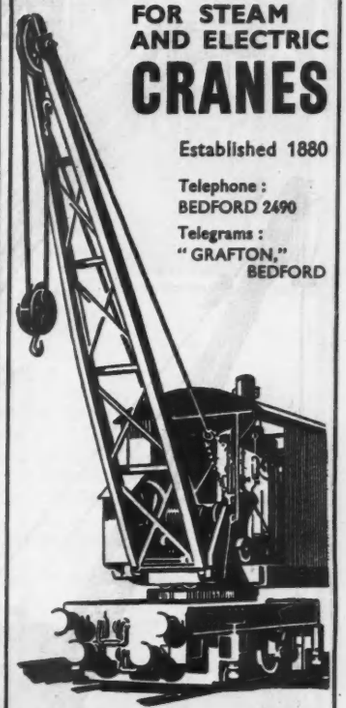

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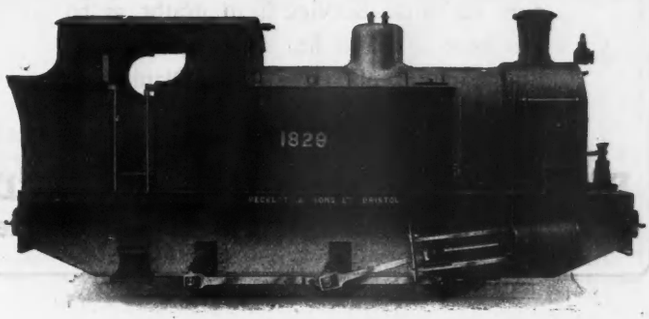

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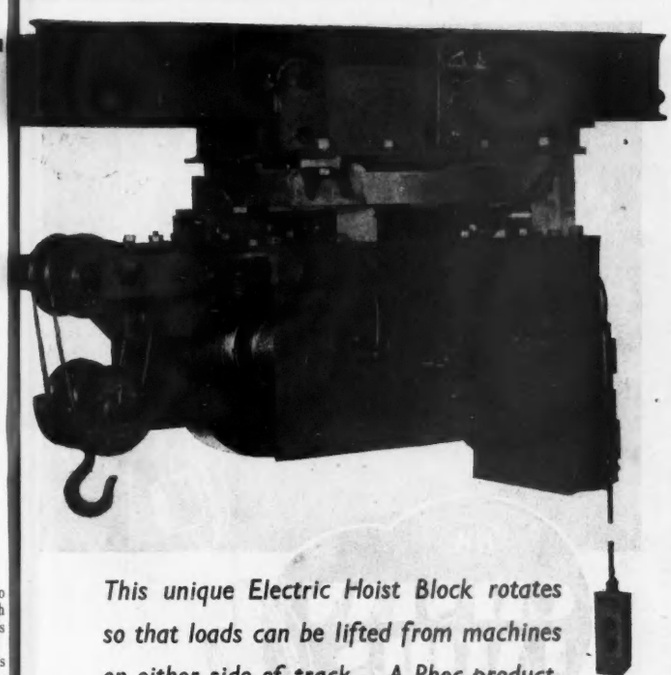

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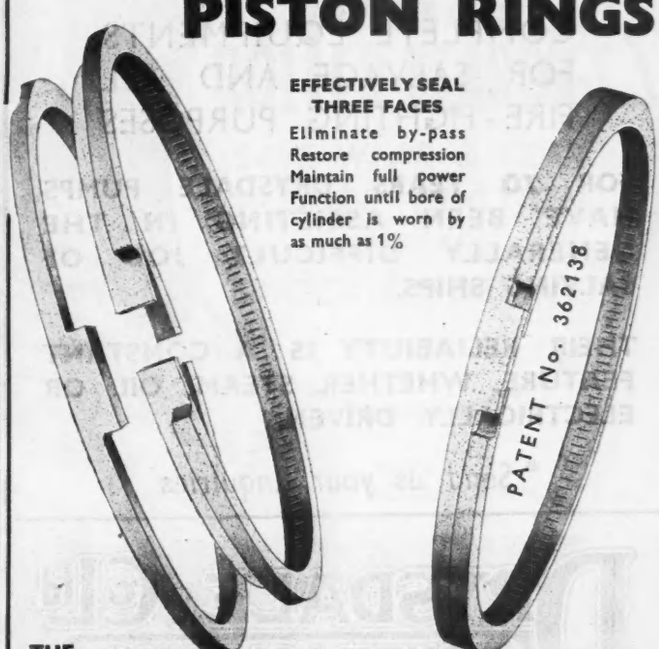

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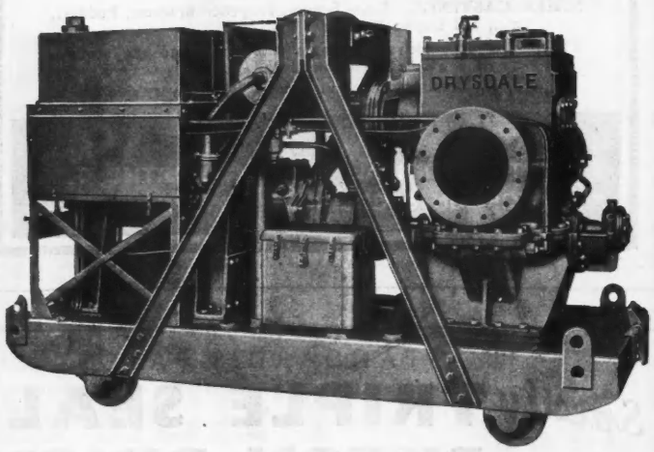

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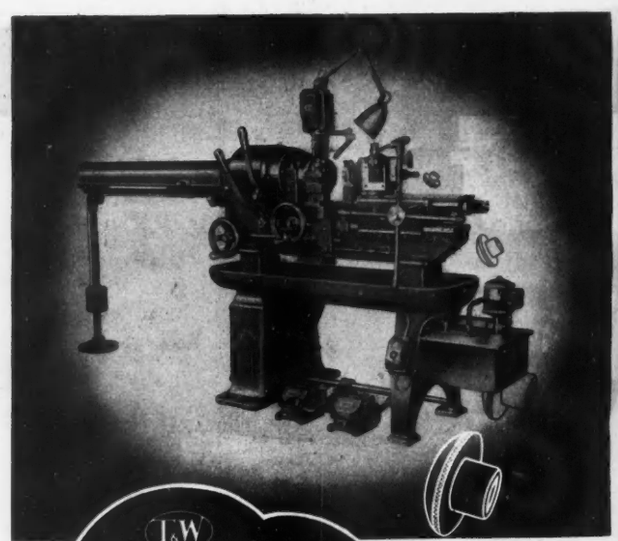

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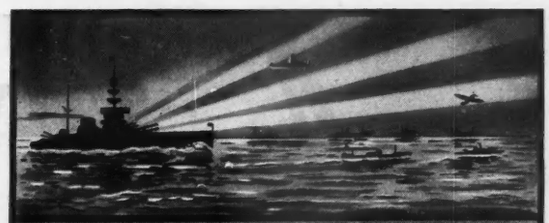

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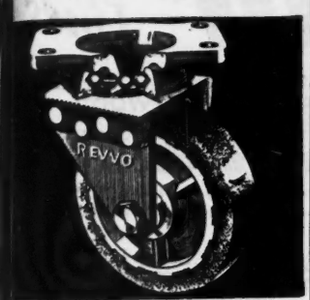

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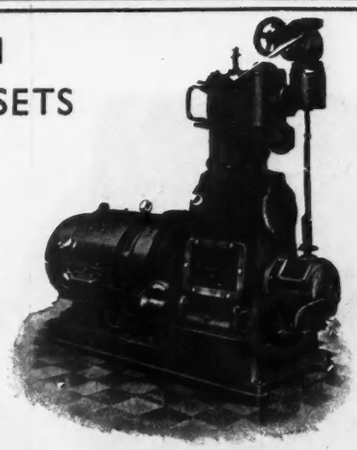

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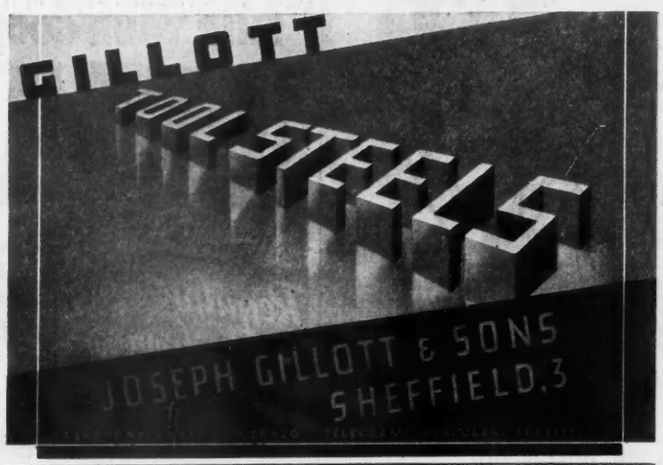

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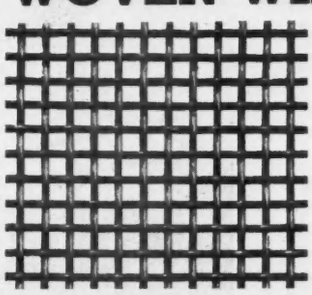

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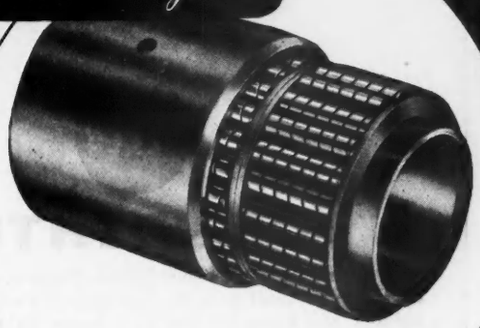

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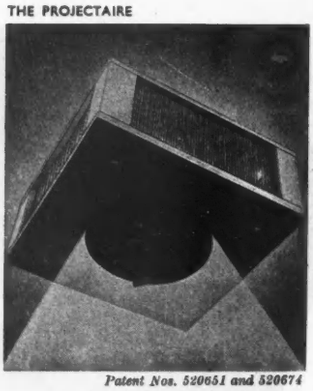

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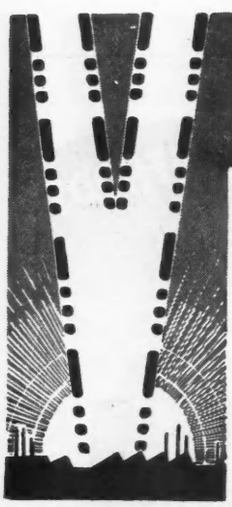

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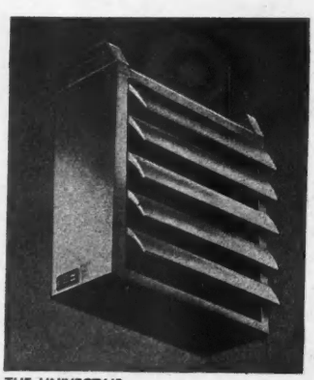

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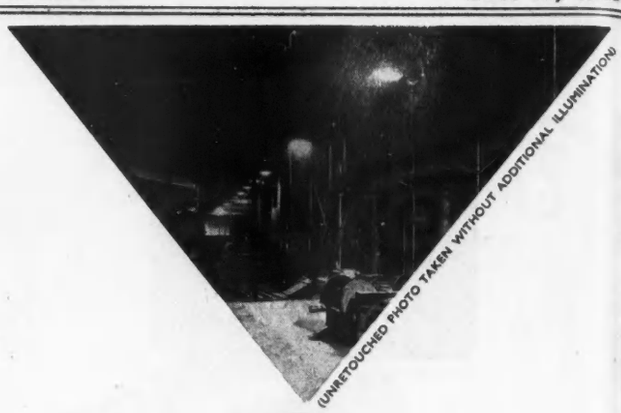

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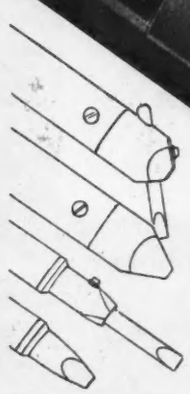

This illustration shows the shape of the standard 240 watt industrial type Solon Electric Soldering Iron. There are five standard models. All are exhaustively tested under rigid workshop conditions; each is subjected to a pressure test of 600 volts to earth for one minute to conform to Home Office requirements. The Solon is quicker, simpler, safer, maintains constant heat at the point. All internal connections are in the bakelite terminal box—away from heat. Complete with 6 feet of HENLEY tough rubber-sheathed 3-core flexible. Made for the following standard voltage ranges 100/110, 200/220, 230/250

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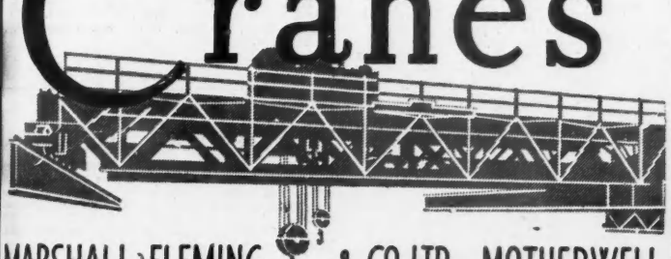

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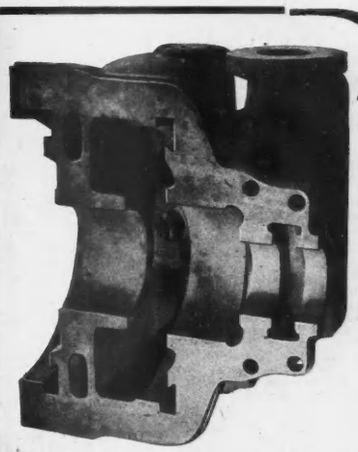

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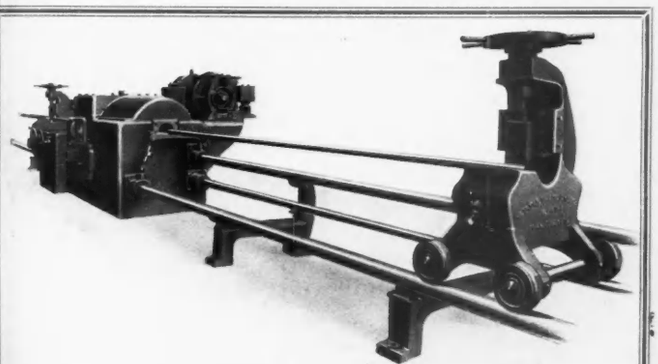

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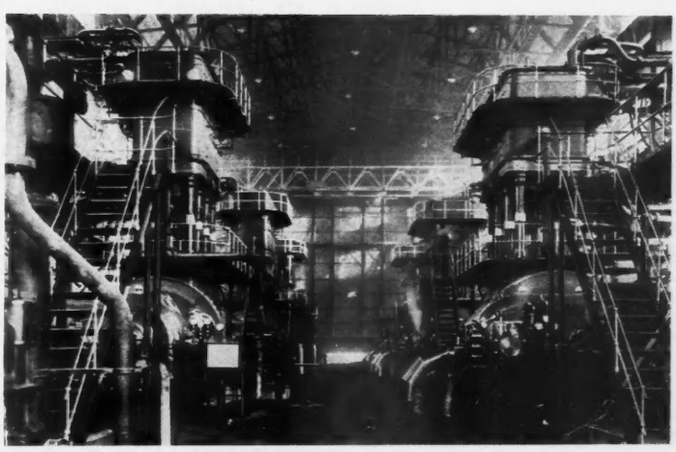

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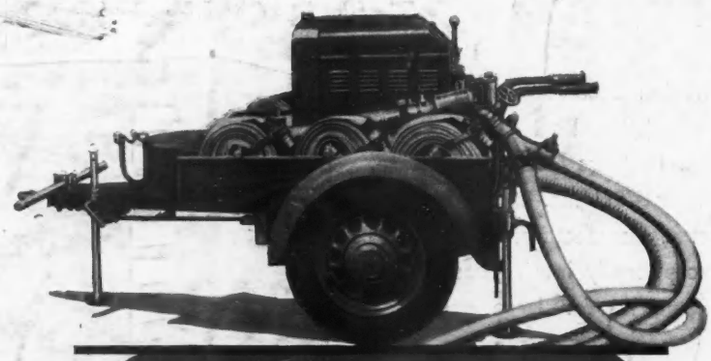

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